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Photo: C. Vibe

Fig. 1. Young Thule girls in front of a skin tent.

THE FRENCH GEOGRAPHICAL EXPEDITION TO THULE, 1950-1951: A PRELIMINARY REPORT

J. Malaurie*

THE French Geographical expedition to Thule in 1950–1951 was organized to develop and extend field studies that had been carried out in the Disko Bugt area of west Greenland in conjunction with the Paul Emile Victor expedition of 1948–1949. The plans were approved by the Comité national de Géographie française and financial support was received from the Centre National de la Recherche scientifique française. On 1 June 1950 the necessary authorizations were granted by the Danish government, and I wish to thank Eske Brun, Director of Grønlandsdepartementet, for the various facilities, particularly transport, that he made available.

I left Copenhagen by ship on 1 July 1950, arriving at Thule on July 23. Winter quarters were established at Siorapaluk 125 miles north of Thule, and from here long distance trips were made with sledge and dogs during the winter months through the inhabited parts of the Thule area to collect demographic and social data on the Eskimo. In the spring Siorapaluk was used as base for a geomorphological expedition to Inglefield Land, Washington Land, and to Ellesmere Island. I finally left Thule on 15 July 1951, having completed my research program. This paper summarizes the results of the expedition; detailed results have been published elsewhere.[1]

Demography and human geography

The Polar Eskimo who live in the Thule area on the northwest coast of Greenland are the world's most northerly inhabitants. Between October 1950 and February 1951 I visited all their camps, spread over the 250 miles from Etah to Savigsivik, and was able to assemble complete demographic data on the population. According to the nominal and genealogical census I drew up on 31 December 1950, there were 302 Eskimo living at ten different settlements: Etah, 21 inhabitants; Neke, 10; Siorapaluk, 34; Kangerdluarssuk, 12; Kuinassuk, 14; Kekertat, 17; Nunatarssuak, 3; Thule, 137; Kekertak, 13; and Savigsivik, 41 inhabitants (Fig. 2).

The Eskimo of the Thule area were situated on the migration route by which all native groups reached Greenland from Canada. According to Holtved, Eskimo appear to have travelled by this route to northwest Greenland "prior to the year 1000 A.D." and by the twelfth and thirteenth centuries a distinct early Thule culture had developed (Holtved, 1944, pp. 177–8).

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[1]Malaurie, J., L. Tabah, and J. Sutter. 1952. "L'isolat esquimau de Thulé (Groenland)". *Population* (Paris), Vol. 7, pp. 675–692.

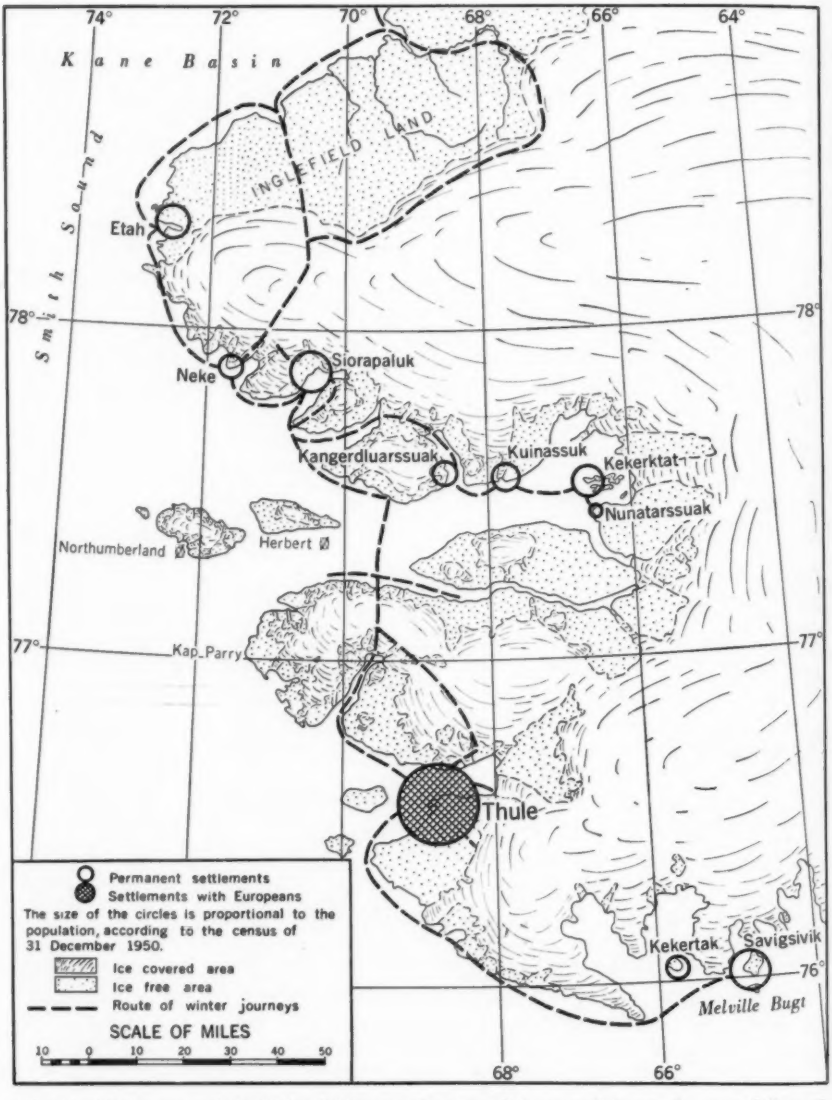

Fig. 2. Settlements of the Polar Eskimo at the time of the expedition, and routes followed during the winter months.

Evidence suggests that after 1600 the Polar Eskimo were cut off from regular contact with the west coast of Greenland. They were not discovered by Europeans until 1818 when Sir John Ross came across his "Arctic Highlanders" (Ross, 1819, pp. 164–87).

The first nominal census of the group was taken by Peary in 1895. It shows a total of 253 persons, 140 male and 113 female. A second census taken by Peary in 1897 gave a total of 234 inhabitants, and a third census in 1906, a population of 207 (Peary, 1907, p. 393; Steensby, 1910, p. 256). Rasmussen counted 235 inhabitants in 1918, and 251 in a census taken five years later. He thought that the natural increase over this period had been reduced by an influenza epidemic brought from Europe after the First World War. Accurate data is not obtainable before 1895, but archaeological evidence indicates that the population at the close of the eighteenth century was numerically similar to that of the first census. Calculations, which were certainly incomplete, by Kane (1856, Vol. 2, p. 211) of 140 Eskimo, by Hayes (1868, p. 448) of 100 Eskimo, and by Bessels (1875) of 102 Eskimo should all be considered minimum figures.

The first official census by the Danish administrators was taken on 1 October 1930 and gave a total of 266 natives. My direct count of the Polar Eskimo in 1950–51 gave a total of 302 people. During the survey each Eskimo was asked for details of his ancestors and descendants. This information enabled me to trace back a genealogy for four or five generations. The whole genealogy was represented on a circular chart with every three years from 1850 to 1950 marked by a circle (Fig. 3). Each living or dead Eskimo is indicated by number and symbol, according to sex and origin (descendant of Greenlander or European) on the circle corresponding to the year of birth. Each individual is linked to his children by a group of straight lines. Thus, all the details about the birth-rate, age of parents at the birth of each child, sex, length of intergenetic intervals, the number of children in the family, and the number of half-breeds can be shown on one chart.

The chart also permits an easy calculation of the consanguinity coefficients of individuals and couples, as well as the average co-efficient of consanguinity. For events in the past, calculations were made on the following basis: the average age of the mother at the birth of the first child is 18 years, and of the father, 23 years: the average genetic interval is about 32 months. Figure 3 shows a fragment of this genealogy as it concerns Pualuna, an Eskimo bearing the number 1.

Born in 1872, and still alive at the time of the expedition, Pualuna had an excellent memory; he was well informed on all the questions of geneology and was extremely useful during this study of the demography of the tribe. His father came from a family of 3 children; his mother was one of 9 children, of whom 5 had a different mother. Pualuna was the eldest of a family group of 6 brothers and sisters. He had 4 wives. By his first wife, bearing the number 2, Pualuna had 2 children, one of whom died very young, while the other, later, had 11 children. By his second wife, number 3 (Fig. 3), who was already the mother of 3 children, Pualuna had a daughter, who herself became the mother of 3 children. By his third wife, number 4, Pualuna had 3 children, the first of whom had 7 children, the second died young, and the third had 6 children. Pualuna had no children by his fourth wife, not represented in Figure 3, but she was already the mother of 6 children.

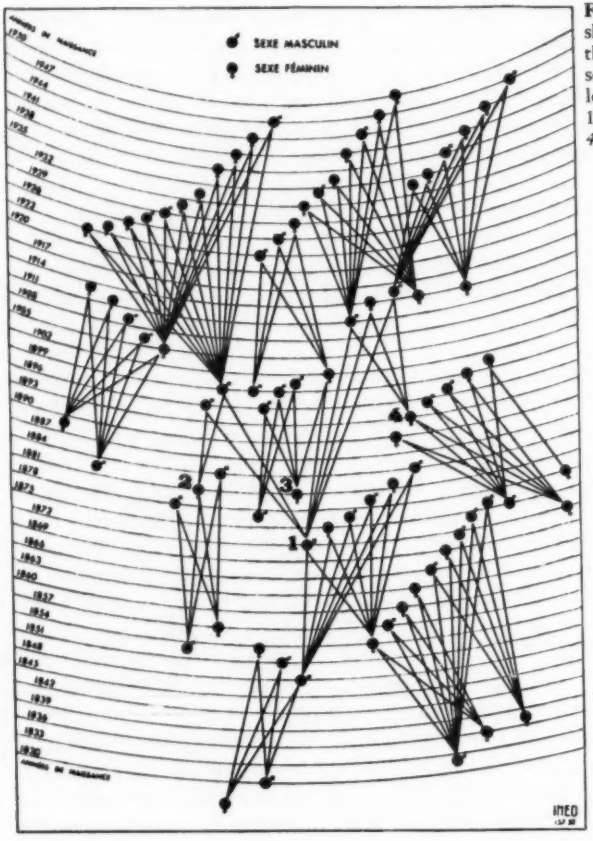

Fig. 3. Part of a circle showing the genealogy of the Polar Eskimo. This section shows the genealogy of Pualuna, number 1. From *Population, No. 4, Oct.-Dec. 1952, p. 690.*

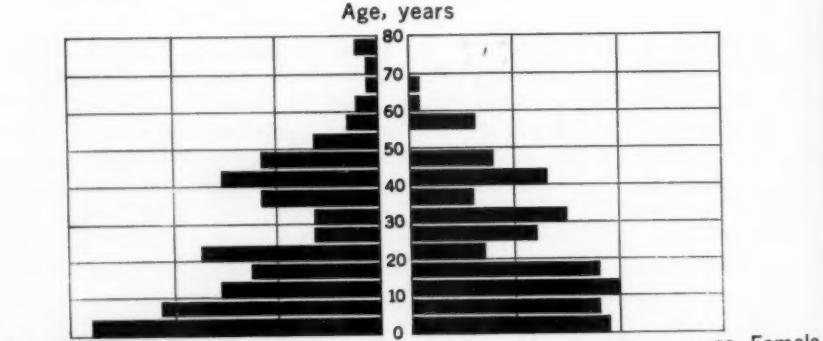

Fig. 4. Pyramid of age for the Polar Eskimo (census J. Malaurie).

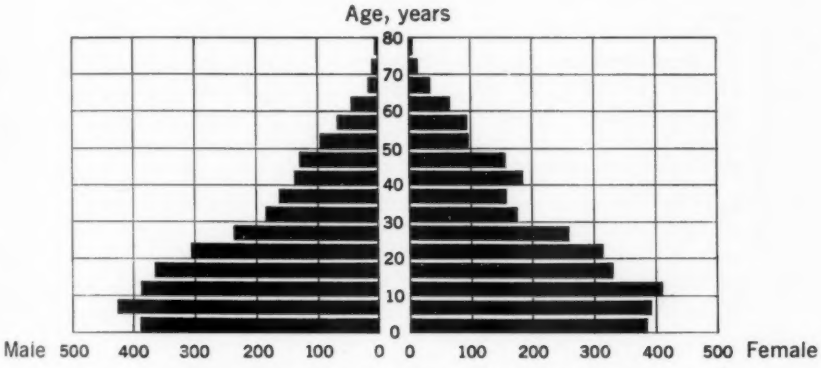

Fig. 5. Pyramid of age for northern Greenland.

This information has only a relative value for the third and fourth generations, compared with data collected for populations where demographic events are normally registered. Nevertheless, numerically, these results enable minima figures to be established. Figure 4 shows a population pyramid for the present population, very indented in shape because of the few subjects in each age group; it can be compared diagrammetically with that for northwest Greenland, south of Melville Bugt (Fig 5) (Denmark. Grønlands Styrelse, 1947). Figure 5 shows a broad-based, obtuse-shaped pyramid, characteristic of a population with a high birth-rate and a high death-rate.

The collected information is of great value in the studies of isolated groups, now being carried out at the Institut National d'Etudes Démographiques in Paris; it illustrates the influence of the size of the population on family relationships, degree of consanguinity, and of genetic homogenity (Tabah and Sutter, 1950; Sutter and Tabah, 1951). As the study of isolated groups or of minimum population is still concerned with genetic theories, it will be interesting, in the light of data from this group, and the second, third, and fourth generations of other isolated groups of primitive people, to clarify controversial questions like the Hardy-Weinberg law on the distribution of genes, and the selection and choice of marriage partners in the Eskimo environment. The chart, of which Figure 3 is a part, should not be considered on the scale of an individual but of the entire group.

Livi (1949, p. 755) queried the numbers of people necessary and sufficient in a reduced group to ensure the biological maintenance of the species. The writer formerly thought that more than 500 people were necessary, and that isolated groups of 300–500 were unstable. The study of the Thule population shows that these figures were too exact. The factors that balance the number of people making up a given group are far too variable and complicated (sex ratio, choice of marriage partner, economic conditions) for any narrow limits to be fixed *à priori*.

At Thule, as in all Eskimo groups, a celibate person is an anomaly. Among the people over 30 years old in 1950, 6 cases of celibacy were noted—4 men and

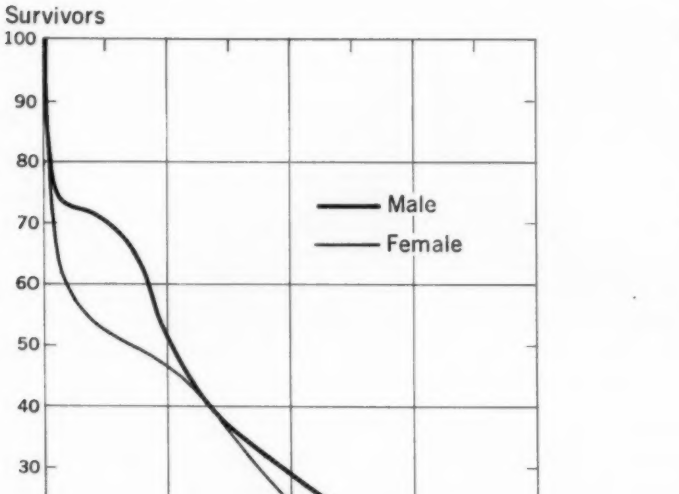

Fig. 6. Survival curve for the Polar Eskimo.

2 women, of whom 3, 2 men and 1 woman, were malformed. As in northern Canada, birth appears to have a seasonal character, the three winter months (January, February and March) being those with the greatest number of births (Robinson, 1944, p. 17). The period of conception is usually spring, when the sun returns, and resources are greater, and the travelling begins again.

The fertility rate, 173 per 1,000, is low for a population with a high marriage rate and which, apparently, knows nothing of contraceptive practices. It can be partially explained by the comparatively high rate of sterility. Out of 51 women who had reached their fertile period, 8 were sterile, a proportion of 16 per cent. If the sterile group is omitted, a rough calculation of the fertility rate gives a figure similar to that generally found in non-Malthusian groups, about 300 per 1,000.

The intergenetic interval is long; in the 106 intervals between birth for which the data was sure the intergenetic interval was 31.8 months. This is due to the prolonged nursing period, and the interval would be even longer were it not for the heavy infantile mortality. The average number of children for women over 45 years of age was between 4 and 5, whereas a century ago the Canadian women of the Province of Quebec, with a fertility fairly close to physiological fertility, had an average of 8 children by the time they were nearly 50 years old.

The gross death-rate for the 11 years from 1940–1950 was 27 per 1,000. This figure appears low when compared with a rate of 31 per 1,000 for the

west coast of Greenland from 1912–1921. It is, however, possible that the comparison is invalidated by the youthful composition of the Thule population and that a better index is a theoretical death-rate computed for a static population and based on the expectation of life at birth. The theoretical rates are 36 per 1,000 for men and 46 per 1,000 for women; and the expectation of life at birth for men is 26 years and for women 22 years. These figures show clearly that the women have a *predisposition to earlier death*; this is contrary to nearly all populations studied, including the other groups in Greenland. Amongst men the death-rate increases rapidly from the age of 18 onwards, due to hunting accidents. The survival curve for women is more regular although more abrupt, and from the age of 12 onwards is nearly linear (Fig. 6). Of 100 women 18 years old (the average age at the birth of the first child) 77 survive to reach the age of 50, and of 100 women 23 years old, 75 reach the age of 35.

Eskimo women who reach the age of fertility have an average of 5 children and therefore the gross rate of reproduction is 2.5. However, when the death-rate is taken into consideration, the net rate of reproduction is only slightly greater than unity. The renewal of the population is therefore ensured with only a small margin of security. Calculations show that the Thule population multiplies at the very low rate of 0.8 per cent, and has been, and still is in a precarious demographic position, like most small isolated communities.[1] The future of the Polar Eskimo appears to depend on increasing the size of the group so that it can survive epidemics and other brief but catastrophic rises in the death-rate. However, it is not at all sure that the local resources of the area can support an increased population.

Until recent years the Polar Eskimo were a good example of an isolated archaic society. The people were semi-nomadic and dependent on hunting walrus, seal, foxes, and more rarely, bear and caribou. When Knud Rasmussen founded the Kap York trading station in 1910 a barter economy was introduced into the area. The Eskimo became aware of the material benefits of western civilization, and today he is depending more and more on fox trapping to supply him with trade goods. In the Thule district game is plentiful and the people are prosperous. In 1909–10, 347 blue fox and 64 white fox skins were traded; in 1947–8, 722 blue fox and 212 white fox skins were traded (Denmark. Grønlandskommissionens Betækning, 1950, pp. 52–3). Between March 1950 and March 1951 the revenue from skins (fox and seal), articles such as narwhal and walrus tusks, souvenirs, and work, whether year-round employment by the Danish administration or occasional employment, such as unloading ships and making dog-team trips for the doctor or pastor, was 129,248 Danish Kroner. This was divided amongst 63 native families, and inquiries revealed that the average income per family per year in the different settlements was as follows: Thule, 1,800 Danish Kroner; Savigsivik, 2,640; Etah, 1,650; and Siorapaluk, 2,450 Danish Kroner per family. Despite the apparent economic prosperity of the Polar Eskimo the future is uncertain. If the population increases, or the needs

[1] A number of Polar Eskimo (about one third of the group) joined Peary's north polar expedition in 1905–6 and sailed away on his ship. If many had died, or had not returned, the group would have been doomed.

of the present people grows the local resources may not be sufficient, and in the harsh environment of northwest Greenland there are no natural other resources to which the Eskimo can turn, as he has been encouraged to do in southwest Greenland; here cod fishing and the raising of livestock have been introduced to take advantage of the change in climate.

Even if the society is able to retain its present economic prosperity it is, however, threatened from within its own structure. The school, the church, European expeditions to the area, and the introduction of modern techniques have all created a state of latent traumatism within the group, and under these repeated shocks the archaic society has begun to disintegrate. The traditional frames are still in existence, but only because of the isolation and segregation which the Danish administration has maintained. Signs of disintegration are visible in the discredit and disappearance of the *angakoks* (shamans) and the decrease in respect paid to the most successful hunters. Instead the younger people now respect the man who is most Europeanized and has scholastic ability, a bank account or administrative responsibility. Individual hunting and trapping is replacing collective hunting and the spirit of solidarity once upheld by common interests is becoming dulled (Malaurie, 1956).

This was the economic and sociological situation in 1951 when a Danish-American air station was constructed first at Thule, and later in Inglefield Land. The construction of these stations makes the future of the Eskimo even more uncertain. The immediate break up of the group in 1951 was avoided only by the policy of the local administration to forbid physical contact between the Eskimo and men of the air station. A temporary solution was found when the Eskimo decided to move 126 miles to the north creating a new settlement at the old village of Kanak (Rosendahl, 1954). The problem, however, still remains for psychological contact has been made; the permanent solution must lie in the planned integration of the Eskimo into the modern world. Shock contacts must be avoided, but integration must come before

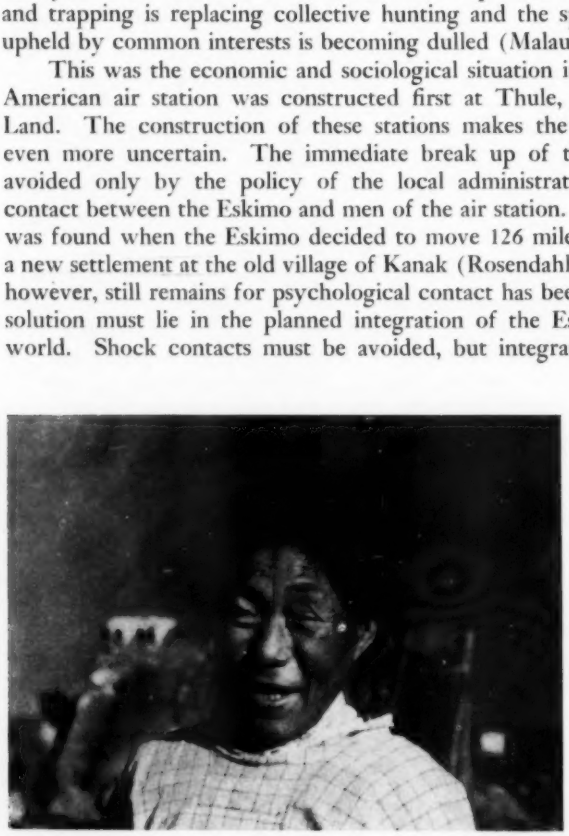

Fig. 7. Avortungiak, an Eskimo woman born in 1895 and living at Etah.

the present society is too degraded. Tests on the drawing of topics by school-age children,[1] after Rorschach (1921), Prudhommeau (1947), and Zazzo (1948), and the observations of the local administration emphasize the natural facility of the Eskimo for adaptation, as shown by their mechanical aptitudes, the ease with which they learn foreign languages, and their good will. Commercial fishing is not possible as an economic substitute for trapping, but some substitute must be found if integration with our society is to be successful and the Eskimo is to remain in the Thule area. Perhaps the answer lies in the development of international polar air routes which might use Thule as a refuelling stop. Certainly new opportunities for the native are offered by the existence of the air station (Malaurie, 1954), but care is necessary to ensure that the opportunities benefit the Eskimo and do not lead to poverty and break up the group.

Geomorphology

During the spring a number of journeys were made by dog team and on foot around the Kane Basin and over the inland ice to carry out geomorphological surveys. To add to the knowledge of the sea ice and the interpretation of the landscape and the geomorphic processes at work five maps were prepared, on a scale of 1:100,000, covering the coastal area of Inglefield Land, the front of the Humboldt Gletscher, and the southwestern part of Washington Land. These maps were prepared from the Map of North Greenland (Koch, 1932), United States Air Force World Aeronautical Charts, oblique air photographs,[2] and details were added by exploratory survey techniques employed in the field. Form lines were drawn in from altitude determinations with two aneroid barometers which had a probable error of about 75 feet. The first of these maps has now been published,[3] and final editions will soon be issued on a scale of 1:200,000.

The most significant factor in the geomorphology of northwest Greenland (Inglefield Land) at the present time appears to be the extreme aridity. Detailed climatological figures are still lacking, but Inglefield Land probably has about 4 to 5 in. (100 mm.) of precipitation in a year—practically a desert climate. The effective precipitation is even less as much of the snow is blown away by winds; it has been estimated that nearly half the snow on the ground in early June is blown on to the sea ice. The summer rains contribute little. At Thule in July 1950 a total rainfall of 0.78 in. (19.7 mm.) was recorded, July being the wettest month. The heaviest precipitation recorded in a twenty-four hour period was 0.22 in. (5.59 mm.). Such small amounts of water have almost no direct geomorphological effect.

[1]The complete results of these psychological investigations will be published elsewhere.

[2]These photographs were kindly lent to the expedition by the Geodaetisk Institut, Copenhagen.

[3]Malaurie, J. 1953. "Présentation d'une carte de la région littorale de la Terre d'Inglefield (N.W. Groenland) au 1/100,000e et d'une carte de l'état des glaces de mer au large du dit littoral". *Comptes Rendus de séances de l'Académie des Sciences*, Vol. 236, pp. 2383–5.

Although it might be thought that wind erosion would be effective under these arid conditions, a microscope study of sands collected by the expedition showed a strong predominance of unworn over worn grains in a ratio of 9 to 1. The absence of any wind-rounded grains in recently formed or fluvioglacial sands indicates that there is no intense wind erosion today. As wind erosion in parts of northern Greenland is very pronounced (Fristrup, 1952–3) it is probable that the lack of erosion in the Inglefield Land may be due to low wind velocities.

Fig. 8. The Algonkian erosion surface, Inglefield Land, at the edge of the inland ice.

At present the Greenland inland ice reaches the sea to the south of the Kane Basin in Prudhoe Land, between Etah and Siorapaluk, and on the northeast of the Kane Basin in the Humboldt Gletscher. Inglefield Land lies between these two areas of ice; it is an ice free strip of plateau coast, thirty-five miles wide, and about 1,000 to 2,00 feet high, reaching 4,000 feet near the inland ice in the southern part of the Kakaitsut area. Glacial deposits are common throughout Inglefield Land, and it is clear that the inland ice recently covered the whole area. The plateau, which is part of the exhumed Algonkian erosion surface first reported by Koch (1933) and studied again by Troelsen (1950), has a remarkably unglaciated appearance (Fig. 8). Only in valleys and other preglacial depressions has the ice left erosional evidence of its presence. The limited erosive action of the ice is also shown by the absence of frontal moraines between the inland ice and the ice free plateau today (Fig. 9). There is a considerable quantity of moraine on the plateau in the form of a discontinuous, coarse rock mantle, but it apparently originated as ground

moraine, carried from the interior of northern Greenland, and was left on the Inglefield plateau as the ice wasted. It was this material that probably formed the corasive agent at the base of the ice when the valleys were glacially enlarged.

Although the Algonkian erosion surface shows that glacial erosion in the region has been limited, it also suggests that periglacial clastic erosion has also been insignificant. To test this conclusion laboratory experiments are at present being undertaken on basalt, sandstone, limonite, chalk and two varieties

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Fig. 9. Etah Fjord, north of Kap Alexander, showing the Algonkian peneplain of Inglefield Land and the inland ice. Note the absence of frontal moraine.

of limestone to determine how readily they shatter under different temperature and moisture conditions. Although the experiments have not yet been completed so far they support the conclusions obtained in the field, that frost action in north west Greenland is weak and occurs only near the surface. Frost action is not only limited to the surface in horizontal strata, but also in talus covering steep rock slopes, which appears to be developing very slowly if at all.

Some slopes in Inglefield Land are retreating under the present climatic conditions. These are the slopes formed in the alluvial sands, and they are numerous especially in the lower parts of the main valleys. Although the available moisture is low and sand is extremely porous, the permanently frozen ground with ice included maintains a water table in summer within a few inches of the surface, and water erosion produces steep slopes which undergo parallel recession. This process is active during a few weeks in the year only. It is in sharp contrast with southern Greenland where the warmer summers

lead to a deeper active layer, and consequently limited fluvial erosion and enhanced solifluction (Malaurie and Guillien, 1953).

The processes in operation in Inglefield Land today seem in general to be insufficient to account for the present landscape. This landscape can only be explained by reference to the geological past and the formation of a Precambrian land surface that has subsequently been exhumed and modified under slightly damper conditions than prevail at present.[1] This may possibly have occurred in interglacial or immediate postglacial times.

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A STUDY OF THE TYPES OF TUBERCLE BACILLI FOUND IN HUMAN TUBERCULOSIS IN ALASKA

Ralph B. Williams*

TUBERCULOSIS is the major health problem in Alaska. Table 1 (*Alaska's Health*, 1955) compares active tuberculosis newly reported per 100,000 population in the United States and its Territories for 1954. The records of the Division of Tuberculosis Control, Alaska Department of Health, prior to 1954 do not contain a breakdown of bone and joint, pulmonary, and other forms of tuberculosis. During 1954 a total of 760 new cases were reported, and 40 of these were extrapulmonary. There were 20 meningitis, 10 bone and joint, 2 genito-urinary, 2 pericarditis, 1 peritonitis, and 5 unclassified (throat). A case with extrapulmonary and pulmonary disease was recorded as one, but as pulmonary tuberculosis. Weiss (1953) shows that the majority of the cases are among Eskimo, Aleuts, and Indians living in the outlying areas. Aboriginal health problems in Alaska are those of a people who maintain their primitive culture and who have never known high standards of living, or high quality health services. The high rates of skeletal tuberculosis due to human type tubercle bacillus are the results of contact with highly infectious cases of pulmonary disease in isolated communities.

Table 1. Active tuberculosis cases newly reported per 100,000 population United States and Territories, 1954.

Political division	*Cases per 100,000*
Alaska	370.0
Puerto Rico	157.6
Arizona	154.3
District of Columbia	139.0
New Mexico	89.5
Kentucky	83.4
Hawaii	77.2
All other States	Below 70.0[1]
Av. for the United States and Territories	51.0

[1] Idaho reports the lowest number–14.0.

This study was made to try to determine the types of *Mycobacterium tuberculosis* giving rise to the high prevalence of bone and joint tuberculosis in Alaska. The annual reports of the Alaska Department of Health list the physician and clinic treatment of children under 21 years of age for tuberculosis of the bone and joints as shown in Table 2. The highest morbidity exists among the aboriginal races of Alaska. The study was initiated in 1947 as an adjunct to an extensive skeletal tuberculosis program and streptomycin

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chemotherapy study under the direction of Dr. Philip H. Moore, Orthopedic Surgeon, Alaska Department of Health, Mt. Edgecumbe, Alaska. An additional phase was to observe if types, strains, variations, and mutations different from typical *M. tuberculosis* isolated in other regions of the world were producing extrapulmonary disease and the relative frequence of these in human tuberculosis among Alaskans.

Table 2. Tuberculosis of the bone and joints active and unspecified.

	1948	*1949*	*1950*	*1951*	*1952*	*1953*	*1954*
Cases, skeletal (under 21 years)	102	105	151	196	155	182	180

Attention was first directed to the types found in the extrapulmonary cases in small children and young adults brought to medical centres for surgery from all parts of Alaska. Later, series of sputum specimens were included in the study. Although bovine tubercle bacilli are rarely the etiological agents in pulmonary tuberculosis, we thought it was advisable to include samples as part of this investigation.

Materials and methods

The majority of specimens from extrapulmonary tuberculosis, especially bone and joint cases, were received at the Juneau Central Laboratory of the Alaska Department of Health from Dr. Philip H. Moore for diagnostic purposes. Specimens from a limited number of extrapulmonary and all the pulmonary cases were received at random from private physicians as part of their routine practice. Specimens were received, for the most part, in sterile, screw-cap bottles through the mail as soon as possible after collection; however, some were brought directly to the laboratory from the operating room, hospital or physicians' clinics. Some of the material from bone and joint cases was placed in sterile physiological saline to prevent excessive drying while enroute to the laboratory.

Early in the study, pathological materials received were macerated in sterile pyrex tubes containing sterile quartz sand or were ground in a one-inch steel mortar with pestle. The material was directly transferred and rubbed into the surface of slants of Löwensten-Jensen Medium (LJM) (Holm and Lester, 1941) to make good contact between bacilli and medium. The LJM[1] is capable of supporting the growth of human, bovine, avian strains, and other *Mycobacteria*; at the same time growth on this medium permits differentiation of tubercle bacilli from acid-fast and alcohol-fast saprophytes. Sterile diluent was used at first to recover macerated tissues. Later, however, because of contamination and suspected contamination of the pathological specimens it was necessary to use chemical homogenization followed by con-

[1]The Löwenstein-Jensen medium is a solid egg-potato medium, and in the Alaska Department of Health Laboratories we follow Holm and Lester's directions almost verbatim. The failure of most bovine strains to grow in the original isolation, in the presence of glycerine, while the human type prospers on mediums containing this substance, is of the utmost importance in distinguishing the two types by cultural methods. For this reason, all materials suspected of containing bovine tubercle bacilli should be cultured on both glycerinated and non-glycerinated mediums.

centration and cultivation on LJM. It is appreciated that where possible, homogenization with sodium hydroxide or other chemical should be avoided in the isolation of *Mycobacteria* from solid tissues and lesions, because of the marked reduction in the numbers of viable organisms that can be recovered by culture methods. We used a concentration of 3 per cent sodium hydroxide with equal quantities of the macerated and ground tissues with an incubation of 20 minutes at 37°C, before the addition of acid neutralizer (2 ml. H_2SO_4–2 ml. H_3PO_4 to 100 ml. distilled water) and brom thymol blue indicator. The prepared homogenates were centrifuged and the sediment transferred to and well rubbed into the surface of 5 slants of LJM (3 containing 0.75 per cent glycerine and 2 without glycerine). All culture tubes were examined at the end of the second week and every week thereafter for a period of eight weeks. All cultures which were negative at the end of twelve weeks but which were inoculated with material containing moderate to many numbers of bacilli by smear, were washed with sterile diluent and recultured on fresh LJM and additional smears examined for acid-fast bacilli. All slants were incubated in a position horizontal to the surface of the slant for 24 to 48 hours, to bring the seeding sediment into contact with all parts of the exposed surface. The tubes were then held in an upright position for the remaining period of incubation.

The techniques used for the pulmonary specimens are as follows: sputum was collected in sterile 1 oz. glass bottles with tightly fitted screw caps. The specimens as received were decanted into 250 ml. erlenmeyer flasks with rubber or ST glass stoppers, and an equal volume of 4 per cent sodium hydroxide was added to each. The mixture was held at 37°C for 20 minutes with manual shaking at intervals to assure thorough homogenization. Brom thymol blue was added and the contents were brought to a definite yellow colour by slow addition of the acid neutralizer. The contents were then back titrated with 4 per cent sodium hydroxide until the first persistent greenish-blue tinge appeared. The contents were balanced in 50 ml. centrifuge tubes and centrifuged at 2,000 to 3,000 r.p.m. for 15 minutes, after which the supernatant fluid was discarded. Concentrates thus prepared were used for microscopy and seeding of LJM slants. As with the pathological specimens 5 slants (3 with 0.75 glycerine and 2 without glycerine) were seeded and cultivation carried out in an identical manner.

Since tuberculosis in man is almost always caused by mammalian type tubercle bacilli no attempts were made to incubate cultures at temperatures below or above 37°C. Human disease caused by the avian type bacilli are so infrequently encountered (Feldman, 1938, pp. 357–410; Bradbury and Young, 1946) we did not consider that the relative frequency warranted incubation of slants at the higher temperatures.

Smears prepared from the concentrates were made by spreading approximately 0.1 to 0.2 ml. of the material on new glass slides. The smears were stained according to the Ziehl-Nielson technique and on examination not less than 100 microscopic (oil immersion) fields (Corper and Nelson, 1949) were covered. Corper (1928) and Cummings (1949) have estimated that where

fewer than 100,000 acid-fast bacilli per ml. of sputum are present the detection is very difficult by microscopy.

Results

A comparison of the results of the cultural and animal pathogenicity studies as applied to 180 extrapulmonary and pulmonary specimens containing tubercle bacilli is shown in Table 3. The series subjected to animal inoculations at the Tuberculosis Evaluation Laboratory, Communicable Disease Center, U.S. Public Health Service, Chamblee, Georgia, did not contain any bovine type bacilli. However, one of these cultures from sputum on LJM had the typical dysgonic colonial morphology of the bovine type.[1] This culture resembles the transitional forms described by Jensen (1950, p. 68), who believes that bovine can change to human type tubercle bacilli after a period of residence in the human body. Our strain was found to conform with the pathogenicity of the human type and classified as such.

Table 3. Type classification by culture and pathogenicity studies.

Source of materials	*Cases*	*Type*		*Number of cases in different age groups (bovine type bacilli examined for).*		
		Human	*Bovine*	*Less than 5 yrs.*	*5–15 yrs.*	*16 yrs. and over*
Cervical gland	2	2	0	0	0	2
Bone and joint	62	62	0	13	38	11
Genito-urinary	3	3	0	0	0	3
Pulmonary	106	106	0	0	41	65
Miscellaneous	7	7	0	1	1	5
Total	180	180	0	14	80	86

The central and three regional laboratories of the Alaska Department of Health made a total of 43,990 cultural examinations on specimens of all kinds from July 1944 to June 1955 (Table 4). Of this number 5,113 were typical eugonic colonies and 1 was a dysgonic colony of *M. tuberculosis.* These were tentatively classified as human type on the basis of colonial morphology except the one strain which was later classified with the human type on the basis of pathogenicity. Cummings (1949) has pointed out that through routine use of a specific culture medium such as LJM, a qualified bacteriologist can tentatively identify, by colonial morphology, typical human, bovine, and avian species and distinguish these from chromogenic acid-fast saprophytes. Bergey's

Table 4. Cultures of all sources from laboratories of Alaska Department of Health, 1 July 1944 to 30 June 1955.

Mycobacterium isolated	*Negative culture*	*Unsatisfactory culture*	*Total*
5,114	34,469	2,407	43,990

[1]Most of the typical human type strains grow readily and luxuriantly on LJM appearing as large, rough, "cauliflower" colonies. Such growth is called "eugonic". It is dry and friable when picked up with a needle. Bovine colonies grow poorly and appear later than the human type as small, smooth, and pale to cream coloured colonies. This is known as "dysgonic" growth. These growth differences are important in distinguishing the two types of mammalian tubercle bacilli.

Manual (Breed and others, 1948, pp. 876–91) in the key to the genus *Mycobacterium* lists a considerably greater number of acid and alcohol-fast bacilli, other than those responsible for human tuberculosis, the majority of which are saprophytes or non-pathogenic for mammals or birds. It has been recently and adequately demonstrated (Cummings, 1949; Patnode and others, 1954), that sole reliance on colonial morphology is not advisable and the final determinations of the types of *M. tuberculosis* should always be made through the use of healthy laboratory animals.[1]

Table 5. Number or frequency of human and bovine tubercle bacilli in 2,227 cases of human tuberculosis, prepared from figures collected by Möllers.

		0—15 years		*16 years and over*	
Source of materials	*Cases*	*Human*	*Bovine*	*Human*	*Bovine*
Bone and joint	203	108	44	50	1
All forms	2,227	682	195	1,301	29

A total of 30 strains of chromogenic saprophytic *Mycobacteria* were isolated in our laboratories during the period 1 July 1944 to 30 June 1955 from the 43,990 field speciments obtained. The colonies of the acid-fast saprophytes appeared quickly on LJM, producing well-marked differences and thus presented few difficulties in differentiation from genuine mammalian tubercle bacilli. These cultures were classified by the Tuberculosis Evaluation Laboratory to be avirulent by pathogenicity studies.

No attempts were made in this study to pick, for pure-culture specific identification, colonies of acid and alcohol-sensitive commensal microorganisms which had escaped alkaline homogenization.

The incidence of human infections, including pulmonary tuberculosis, due to bovine tubercle bacilli is not known in the United States, according to Feldman and Karlson (1947, p. 239). However, an early study by Park and Krumwiede from 1910 to 1912 (1910; 1911; 1912) indicated the incidence of bovine type tuberculosis in children to be about 6 to 10 per cent. Price (1932) studying tuberculosis in Canada found the incidence of bovine type bacilli to be 14.1 per cent of 268 tuberculous children, while the percentage frequency in 168 tuberculous adults from the same area was only 3.5 per cent. His investigation showed that the individuals with bovine type tuberculosis were using raw milk at the time their illness was diagnosed. Möllers (1928) reviewed the literature on the incidence of human and bovine types of tubercle bacilli in 2,244 cases of tuberculosis in human beings of known groups. Table 5 lists the cases of bone and joint disease and the totals for all forms of tuberculosis. Seventeen cases had infections from which both types were isolated. These were not included in the final tabulations. Studies of recent years show a definite decline in the relative frequency of bovine type tubercle bacilli in human tuberculosis where pasteurization or boiling of milk is practised.

[1]In our study, the 180 cultures of the tubercle bacillus and the chromogenic *Mycobacterium* spp. were referred to the Tuberculosis Evaluation Laboratory, Atlanta, Georgia, for animal confirmation of our cultural findings. The one dysgonic culture and some of the 5,113 isolated prior to the study were likewise subject to animal study, but the remaining cultures were tentatively classified as human type on the basis of colonial morphology.

Table 6. Total tuberculin tests of cattle in Alaska with reactors. Fiscal years 1917–1942.

	Herds tested	*Cattle tested*	*Reactors found*	*Per cent reactors*
1917–42	467	4,756	75	1.6

Total tuberculin tests of cattle in Alaska with reactors

Year	*Cattle tested*	*Reactors found*	*Per cent reactors*
1941	958	4	0.41
1942	1,064	2	0.18
1943	1,302	2	0.15
1944	1,243	3	0.24
1945	1,382	7	0.50
1946	688	0	0.00
1947	1,254	2	0.15
1948	1,017	1	0.09
1949	1,558	2	0.13
1950	1,436	0	0.00
1951	1,192	0	0.00
1952	1,059	0	0.00
1953	1,811	0	0.00
1954	1,436	0	0.00
1941–54	17,400	23	0.13

Gernez (1939) demonstrated that there is a high incidence of tuberculosis in the cattle of France, but a low incidence of human tuberculosis caused by the bovine type tubercle bacilli. He attributes this to the general practice of boiling milk to preserve it, as the percentage rises in areas where such preservation of milk is not a common practice.

In the parts of Alaska where all forms of tuberculosis are highly prevalent, cattle for milk production are exceedingly rare or non-existent. Even though raw milk may not be used by the aboriginal peoples living in these regions, the people are closely associated with animals and handle large volumes of meat which is eaten partly cooked or raw. No cases of tuberculosis have been reported in herds of Alaskan reindeer slaughtered under veterinary supervision, but there are no data on the tuberculosis rates among the other animals which these people use as food.

The low incidence of infections in Alaska, predominately among caucasians and non-natives, living in or near the population centres where dairy cattle are most common, has been determined by tuberculin testing and evaluated by Weiss (1953). Pasteurization is the common practice for most of the milk and milk products commercially distributed in these more populated centres and the sections immediately adjacent. Tuberculin-testing of cattle in Alaska was instigated in 1917 by the Bureau of Animal Industry, U.S. Department of Agriculture, and veterinarians of the Alaska Department of Agriculture have carried on this program since 1941 as shown in Table 6. The upper part of the table lists the numbers of tuberculin-tested cattle with reactors during fiscal years 1917 to 1942, as tested by the B.A.I. and the lower part shows the total numbers of cattle tested by the territorial veterinarians annually from 1941 through to 1954. J. W. Wilson, Commissioner of Agriculture, Alaska Department of Agriculture, Palmer, says that no laboratory studies were conducted on specimens collected at post mortem examination of the slaughtered or destroyed reactors (personal communication).

McPhedran and Opie (1935) state that the spread of tuberculosis occurs in large part by long drawn out family or household epidemics in which the

disease is slowly transmitted from one generation to the next. The source of infection in Alaska appears to be mainly person to person by direct contact in overcrowded living establishments. To a lesser degree, transmission occurs by indirect contact with infected discharges of human beings and animals, especially in the areas of high incidence where substandard environmental conditions are major problems in communicable disease control. Sled dogs may further spread human type bacilli through discharges from their bodies, exposing human beings to infection (Williams, 1946).

Table 7 is compiled from similar studies already published (Blacklock, 1929; Griffith, 1907, 1930; Mitchell, 1914; Price, 1939) in various countries of the world. These figures (not frequencies) indicate that although bovine type bacilli are not a frequent cause of human tuberculosis they play a definite role, especially in countries where pasteurization or boiling of milk is not common and where tuberculin-testing of cattle is not a routine procedure to eliminate positive reactors from herds. The limited numbers of cattle and the annual tuberculin-testing programs in Alaska result in low bovine type tuberculosis case-rates, and it is evident that bovine type *M. tuberculosis* is of minor significance in the problems of over-all tuberculosis control in Alaska.

The finding of saprophytic *Mycobacteria* in pulmonary and extrapulmonary specimens is not unusual. Pinner (1935), processing some 5,000 diagnostic sputum cultures at the Montefiore Sanatorium, New York, reported that 0.9 per cent contained colonies of chromogenic, saprophytic *Mycobacteria*; Lester (1939), isolated 130 strains of saprophytic *Mycobacteria* out of 26,343 specimens from human beings. Of the total 130 cultures, 75 (or 57.7 per cent) were gastric washings, 24 (or 18.4 per cent) were urinary specimens, and the remaining 13 (or 10 per cent) were from pulmonary sources. About one-fifth of the cultures resembled the typical eugonic and chromogenic *Mycobacteria* reported in literature. More recently Scott (1948) has isolated 15 strains of saprophytic *Mycobacteria* out of 1,000 consecutive cultures made for tubercle bacilli at Manitoba Sanatorium, Ninette, Manitoba. Of the 15 cultures, 11 (or 73.3 per cent) were from gastric washings, 2 (or 13.3 per cent) from pleural fluid and 1 (or 6.7 per cent) each from sputum and urine. All but 2 resembled the

Table 7. Human and bovine tuberculosis in man.

	Human		*Bovine*		
Political division	*Number*	*Per cent*	*Number*	*Per cent*	*Total*
Alaska	180	100.0	0	0.0	180
Australia	246	87.9	34	12.1	280
Canada	847	94.0	54	6.0	901
Denmark	4,832	88.2	644	11.8	5,476
England	3,592	97.8	79	2.2	3,671
France	1,055	97.4	28	2.6	1,083
Germany	1,007	86.4	158	13.6	1,165
Greece	327	100.0	0	0.0	327
Hungary	328	98.2	6	1.8	334
Italy	846	97.1	25	2.9	871
Japan	264	97.1	8	2.9	272
Netherlands	701	91.4	66	8.6	767
Norway	101	94.4	6	5.6	107
Poland	149	93.1	11	6.9	160
Spain	90	94.7	5	5.3	95
Sweden	14	100.0	0	0.0	14
Switzerland	201	92.2	17	7.8	218
Wales	201	99.0	2	0.98	203
Total	14,981	92.91	1,143	7.09	16,124

smooth, moist, creamy to orange eugonic strains described in the literature. Guinea pig inoculations were necessary to prove the lack of pathogenicity or virulence of the 2 cultures which did resemble the tubercle bacillus in staining reactions and growth stimulation. Of the 30 cultures isolated in our laboratories in Alaska only 4 (or 13.3 per cent) were from gastric washings, 1 (or 3.3 per cent) from spinal fluid, and the remaining 25 (or 83.3 per cent) were from pulmonary sources which constitute over 95 per cent of the specimen load. The volume and nature of our specimen load may account for the lower percentage of saprophytes isolated from gastric washings when compared with reports in the literature.

A total of 180 cultures isolated from human cases of tuberculosis were classified by colonial morphology and pathogenicity as to type. No bovine, only human type tubercle bacilli were found. The specimens were from the following sources: cervical gland 2, bone and joint 62, genito-urinary 3, pulmonary 106 and unclassified extrapulmonary cases 7.

The laboratories of the Alaska Department of Health isolated 5,114 cultures of *M. tuberculosis* from July 1944 through to June 1955. All these cultures except one have been characterized by the typical eugonic growth of the human type tubercle bacilli. The bovine type bacillus does not therefore have a major role as an etiological agent of public health significance in human tuberculosis in Alaska.

The author wishes to express appreciation to Dr. Philip H. Moore for the surgical specimens and to Dr. Martin M. Cummings and his associates for the valuable assistance through the additional biological and pathogenicity studies made on the cultures isolated. The technical assistance of Frank P. Pauls, James H. Savage, Mrs. Dixie M. Baade, Joseph Chiuminatto, and Miss Beatrice Shepard is greatly appreciated. Appreciation is expressed to Dr. Charles R. Hayman, Cecil Gronvall, Miss Helen Johnson, and James W. Wilson for statistical data used in this paper.

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SOME OBSERVATIONS ON THE SHORE FAUNA OF BAFFIN ISLAND

D. V. Ellis*

THE first trained biologist to examine the shores of Baffin Island was Ludwig Kumlien who was a member of the Howgate Polar expedition 1877–8 which wintered in Cumberland Sound (Kumlien, 1879). Previous to his report at least one collection was known, for Hancock (1846) describes a series of shells brought back from Cumberland Sound by "Messrs. Warham and Harrison, masters of whaling vessels belonging to the port of Newcastle". The German polar expedition of 1882–3 also visited Cumberland Sound and the expedition's doctor, W. Schliephake, collected a few shelled animals (Pfeffer, 1886). Most of the specimens from these last two collections were not from the shore but from shallow water and frequently the exact site was not recorded.

So far this century there are reports from six expeditions. Occasional marine biological collections were made by the *Neptune* expedition of 1903–5 to the eastern Arctic (Dall, 1924). The reports of the Fifth Thule expedition, 1921–4 also contain scattered records and the *Godthaab* expedition in 1928 took shore and offshore animals from Totnes Road, Exeter Sound (Riis-Carstensen, 1931). In 1948 E. Grainger brought back some intertidal animals from Frobisher Bay. However, the two most recent collections were those made in 1951 and 1952 by the *Calanus* expeditions, organized by the Fisheries Research Board of Canada.

From the published reports and a preliminary examination of the *Calanus* shore collections, it seemed probable that the intertidal fauna north of Cumberland Sound differed from that within the sound. The intertidal fauna of the nearby coasts of Greenland is fairly well known, Madsen having described a transition in the intertidal fauna north of Angmagssalik in east Greenland (1936, p. 49) and a similar transition on the west Greenland coast near Upernavik (1940, pp. 7–8). Knowledge of the shore fauna of Cumberland Sound and Totnes Road indicated that the intertidal transition in Baffin Island might be similar to that in Greenland.

From June to September 1953, V. C. Wynne-Edwards and the writer visited Frobisher Bay, Pangnirtung, and several other settlements on the east coast of Baffin Island, collecting shore animals and studying the intertidal environment. The shore or intertidal zone was regarded as the region between high and low tidal levels, and animals collected on the shore by hand or hand net are counted as intertidal animals. The terms "littoral", "infralittoral", etc.

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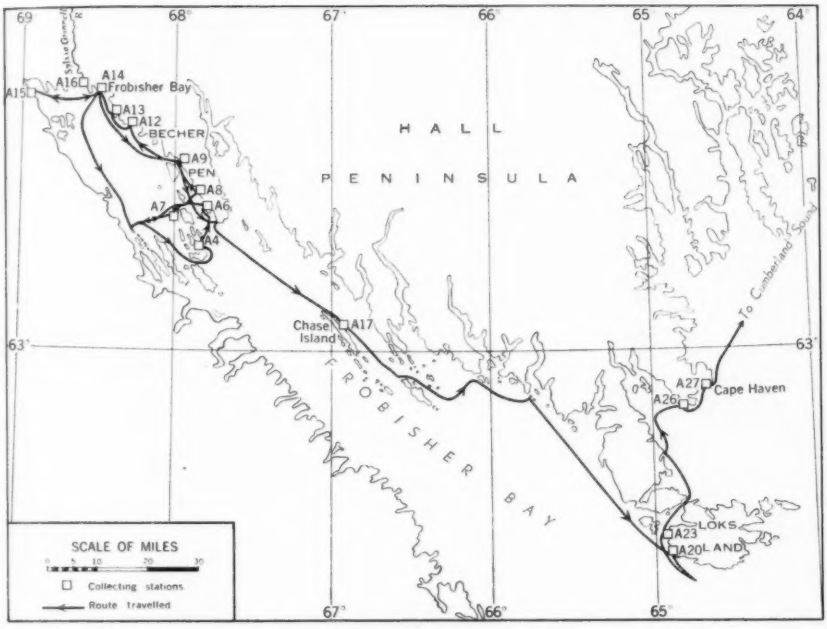

Fig. 1. Collecting stations, Frobisher Bay.

defined by Stephenson and Stephenson (1949, p. 298) are not used in this preliminary study of the shore fauna. We collected from both the north and the south of the expected transition region. The collecting stations are listed in Table 1 and are shown in Figures 1, 2, and 3. Collections were made by hand, supplemented with a hand sieve on sandy shores, and a hand net for fishing in rock-pools. In addition specimens were obtained from a depth of two fathoms or less (i.e. the immediate shallow-water zone) by a small dredge operated from a dinghy in Frobisher Bay, and from a whale boat near Padloping Island.

The Royal Canadian Air Force took me to Frobisher Bay, where I arrived on June 6. I spent the following six weeks travelling round the head of the bay by sled and after break-up by dinghy, during which time ten collections were made. Wynne-Edwards arrived at Frobisher Bay in late July, and on the 24th we set out for Pangnirtung in the Hudson's Bay Company's Peterhead boat *Nanook II*. Additional collections were made in Frobisher Bay and near Cape Haven (Fig. 1). Pack ice and bad weather prevented observations near the entrance to Cumberland Sound, but one collection was made at Miliakdjuin Island (Fig. 2). Nine collections were made in Cumberland Sound, including a second visit to Miliakdjuin Island with the Royal Canadian Mounted Police in their Peterhead boat. A collection was also made at the head of Pangnirtung Fiord by H. R. Thompson, a member of the Arctic Institute's 1953 expedition

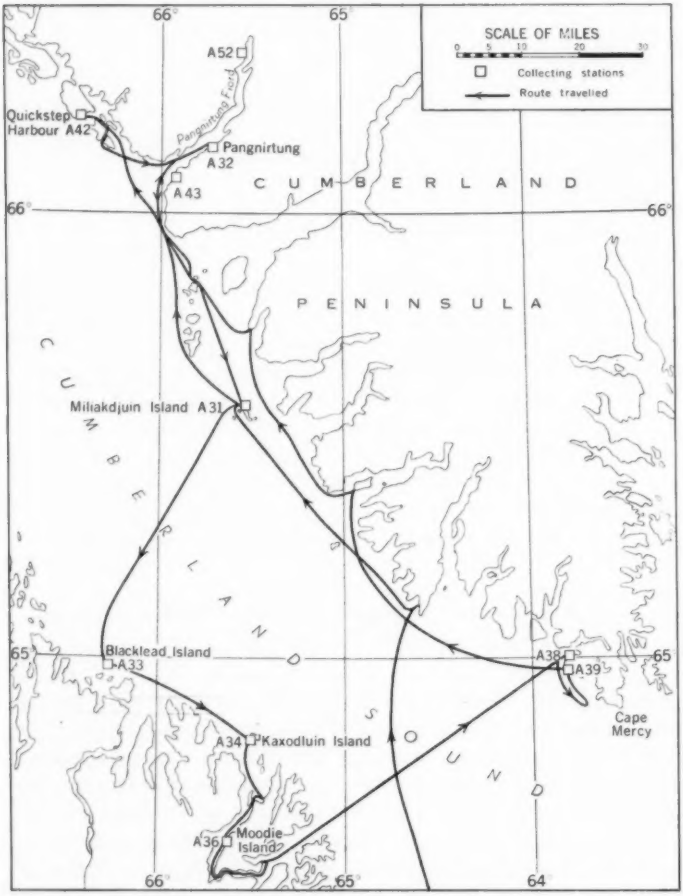

Fig. 2. Collecting stations, Cumberland Sound.

to Baffin Island. On August 13 an R.C.A.F. aircraft took me to Padloping Island, just north of the Cumberland Peninsula, and travelling thence by whaleboat, I made five collections (Fig. 3). On August 26, I boarded the *C. D. Howe* going north on her annual supply voyage, and made brief collections at Pond Inlet, Craig Harbour, and Clyde River before returning to the south.

The Baffin Island collections

The more common species found in 1953 are listed in Table 2, while Table 3 summarizes the present known distribution of the intertidal fauna of Baffin Island. These tables show that the shore fauna in Frobisher Bay is similar to that in Cumberland Sound. North of Cumberland Sound there is a change in the abundance and the variety of shore fauna, and in the vicinity of Padloping Island and farther north the intertidal zone is almost barren.

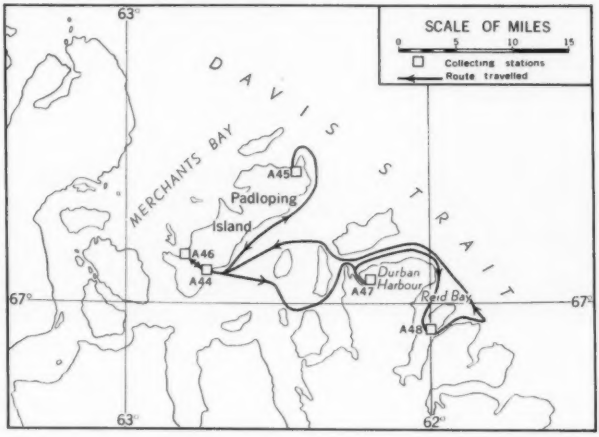

Fig. 3. Collecting stations, Padloping Island.

Table 1. Collecting stations, 1953.

Station	*Date*	*Locality*
		Frobisher Bay
A4	June 16–18	Island west of Becher Peninsula
A6	June 19–21	Becher Peninsula
A7	June 22	Island west of Becher Peninsula
A8	June 26–July 1	Becher Peninsula
A9	July 1–4	Becher Peninsula
A12	July 4	Between Becher Peninsula and Frobisher Bay (settlement)
A13	July 5	Between Becher Peninsula and Frobisher Bay (settlement)
A14	July 6–24	Frobisher Bay (settlement)
A15	July 13	West of Frobisher Bay (settlement)
A16	July 21	Mouth of Sylvia Grinnell River
A17	July 25	Chase Island
A20	July 26	Loks Land
A23	July 27	Loks Land
		Frobisher Bay—Cumberland Sound
A26	July 28	Southwest of Cape Haven
A27	July 29–August 1	West of Cape Haven
		Cumberland Sound
A31	August 3 & 5	Miliakdjuin Island
A32	August 4–5 August 11–13	Pangnirtung
A33	August 6	Blacklead Island
A34	August 6	Kaxodluin Island
A36	August 7	Moodie Island
A38	August 8	West of Cape Mercy
A39	August 8	West of Cape Mercy
A42	August 10	Quickstep Harbour
A43	August 11	Mouth of Pangnirtung Fiord
A52	August 25	Near head of Pangnirtung Fiord (Collection by H. R. Thompson)
		Padloping Island
A44	August 14–26	Padloping Island (settlement)
A45	August 15	Northern tip of Padloping Island
A46	August 17	Southwest Padloping Island
A47	August 19	Durban Harbour
A48	August 20	Reid Bay, southern tip of island
A49	August 27	Pond Inlet (settlement)
A50	August 29	Craig Harbour
A51	September 2	Clyde River (settlement)

The intertidal species of Baffin Island and Greenland

The intertidal species of Baffin Island and Greenland can be divided arbitrarily into two groups that are a convenient means of expressing two different methods of adaptation to the intertidal environment. The two

Species	Collecting Stations: Frobisher Bay 4	6	7	8	9	12	13	14	15	16	17	20	23	26	27	Cumberland Sound 31	32	33	34	36	38	39	42	43	52	Padloping Island 44	45	46	47	48	Clyde River 51	Pond Inlet 49	Craig Harbour 50
Anthozoa																																	
Halcampa arctica Carlgren				x	x	x		x																									
Bunodactis stella (Verrill)	x			x	x	x		x			x		x		x		x	x	x														
Nemertina																																	
Amphiporus angulatus (Fabr.)				x					x					x																			
Ectoprocta																																	
Gemellaria loricata (L.)									x				x					x						x									
Alcyonidium gelatinosum (L.)			x								x						x							x									
Priapulida																																	
Priapulus caudatus (Lamark)		x			x	x		x						x									x									
Polychaeta																																	
Harmothoe imbricata (L.)		x	x	x	x				x		x	x	x	x																			
Eteone longa (Fabr.)				x	x	x		x				x																					
Scoloplos armiger (Mull.)		x		x	x	x						x																					
Capitella capitata (Fabr.)		x		x	x	x			x		x	x																					
Arenicola marina (L.)																	?																
Cistenides granulata (L.)					x												x									d							
Cirripeda																																	
Balanus balanoides (L.)		x	x	x	x	n	n	n	x			x	n	n	x	x		x	n	x		n	n		x	n							
Amphipoda																																	
Pseudalibrotus littoralis (Kroy.)		x	x		x	x	x	n	x	x		x	x			n		x							x								x
Anonyx nugax (Phipps)				x									?																				
Gammarus zaddachi oceanicus Segerstrale		x		x	x				x	x		x					x	x	x		x				x	x							
Gammarus setosus Dementieva		x	x		x				x			x			x		x		x							x							x
Gastropoda																																	
Acmaea testudinalis (Mull.)																	x	x	x				d	x									
Margarita groenlandica (Chem.)								d											x														
Margarita helicina (Phipps)		x	x	x	x		x		x		x	x	x	x	x		x		x				x	x									
Littorina saxatilis (Olivi)		x	x	x	n	n	n	n	n		x	x	n	x	n		x	x	n		x		n	n	x								
Coryphella salmonacea (Couth.)			x	x	x									x				x						x									
Pelecypoda																																	
Modiolaria discors (L.)			x	x	x			x			x	x		x	x			x					x	x		d							
Modiolaria faba (Mull.)		x	x	x	x		x	x	x		x	x	x	x	x		x	x	x		x		x	x							x		
Mytilus edulis L.																	x									x							
Saxicava arctica (L.)		x	x	x	x	x					x			x			x		x				x	x		x							
Mya truncata L.				x	x	x												d					x	x									
Echinoderma																																	
Stephanasterias albula (Stimp.)																																	
Strongylocentrotus droebachiensis (Mull.)																																	
Tunicata																																	
Ascidia callosa Stimp.			x	x										x		x																	
Fish																																	
Myoxocephalus scorpioides (Fabr.)				x				x						x	x		x	x						x		x							
Myoxocephalus scorpius (L.)														x																			
Oncocottus quadricornis (L.)																																	
Gymnocanthus tricuspis (Reinhardt)																																	

Table 2. The common intertidal species observed in 1953: x—collected, n—not collected, d—dead specimen only, ?—identification uncertain.

Fig. 4. Station A14, Frobisher at low water showing the wide tidal flat with scattered boulders. Notice the low hilly country in the background associated with the extensive sandy beaches of this region.

groups also have a distinctly different distribution in the arctic and subarctic. One group includes animals that usually live only between tide-marks and normally die when immersed for any length of time; these are specifically intertidal species and include such forms as the barnacle, *Balanus balanoides*, and the periwinkle, *Littorina saxatilis*. The other group is comprised of species generally found in shallow water, but which can withstand exposure to the air for short periods, and are able to colonize the lower levels of the shores. They are shallow-water forms that occur incidentally on the shores, and include such species as the clam, *Modiolaria discors*, and the scale-worm, *Harmothoe imbricata*. The mussel, *Mytilus edulis*, and some other species do not fit easily into either of these groups, for they occur both between tide-marks and in shallow water.

Madsen used the intertidal transition in Greenland as the boundary between marine arctic and subarctic regions (1936, p. 65). He shows that the intertidal transition on the east coast of Greenland is independent of changes in climate and tidal amplitude. He postulates that it is caused by the mixing of two oceanic currents, the warm Irminger current and the cold East Greenland Polar current. Dunbar (1951) based on Smith, Soule, and Mosby (1937) and on Kiilerich (1939) has shown that marine conditions off west Greenland and at the southeast tip of Baffin Island are similar to those off southeast Greenland, for Atlantic influence has been traced in the water of all three regions. The east coast of Baffin Island can be similarly divided into marine arctic and subarctic regions. Dunbar defines arctic marine areas as "composed of arctic water only, that is to say of water originating from the upper 200 metres of the polar basin; subarctic areas as composed of a mixture of arctic and non arctic water" (1951, pp. 109–10). Dunbar's definition is used in this paper. The terms "high arctic" and "low arctic" used by many European biologists (Lemche, 1941; Ekman, 1953, etc.) to subdivide the arctic region are not used here, and the term "panarctic" refers to species inhabiting both arctic and subarctic regions.

Table 3. The present known distribution of the commonest shore animals in Baffin Island, based on previous collections (o) and those made in 1953 (x).

Species	*Frobisher Bay*	*Cumberland Sound*	*North of Cumberland Sound*
Anthozoa			
H. arctica	x	o	
B. stella	x	xo	
Nemertina			
A. angulatus	x	o	
Ectoprocta			
G. loricata	x	xo	
A. gelatinosum	x	xo	
Priapulida			
P. caudatus	x	xo	
Polychaeta			
H. imbricata	xo	o	
E. longa	xo		
S. armiger	xo	o	
C. capitata	x	o	
A. marina		o	
C. granulata	x	xo	x o
Cirripeda			
B. balanoides	x	xo	
Amphipoda			
P. littoralis	xo	xo	x
A. nugax	x	o	
G.s. oceanicus	xo	xo	
G. setosus	xo	xo	x
Gastropoda			
A. testudinalis		xo	
M. groenlandica	x[1]	xo	o
M. helicina	xo	xo	xo
L. saxatilis	xo	xo	
C. salmonacea	x	xo[2]	
Pelecypoda			
M. discors	x	xo	x[1]
M. faba	xo	xo	x
M. edulis		x	x
S. arctica	x	xo	x
M. truncata	x	xo	
Echinoderma			
S. albula		o	
S. droebachiensis		o	
Tunicata			
A. callosa	x	xo	
Fish			
M. scorpioides	x	xo	x
M. scorpius		x	
O. quadricornis		o	
G. tricuspis		o	

[1] Dead specimens only.
[2] Uncertain record.

The shore animals of Baffin Island differ from those of Greenland. *M. edulis* is found in shallow water in Baffin Island as far north as Pond Inlet, but has not been found north of the transition in east Greenland. The lug-worm, *Arenicola marina*, is a rare intertidal species in Baffin Island, whereas it is fairly abundant south of the transition in east and west Greenland (Madsen, 1936, p. 55; Steven, 1939, pp. 59–60). Molluscs were found on the shore at Padloping Island; Madsen states that they do not occur intertidally north of the transition in east Greenland. A barren zone extending to two fathoms below low-water level similar to that along the entire coast of east Greenland, is only found north of Padloping Island in Baffin Island. These differences suggest

Fig. 5. Beach at the mouth of Cumberland Sound near Station A36. Typical fiord country with steep rocky beaches. High water mark is revealed by white line at left, created by ice scraping off the lichens and algae that would normally grow on the rock.

that Madsen's theory about the shore fauna and the underlying currents does not completely explain the transition in Baffin Island.

Factors affecting the distribution of the shore animals in Baffin Island compared with Greenland

Among the environmental factors affecting the distribution of shore animals air temperature and precipitation are probably the least significant. Madsen (1936) shows the transition on the east and west coasts of Greenland to be independent of air temperature and precipitation. A comparison of data from Rae (1951) with those from Madsen (1936) shows that the Baffin Island coast is colder and drier than the Greenland coasts at the same latitudes and the transition occurs in regions with different annual mean temperatures and precipitation.

The observed transition was independent of change in the physiography. In the upper parts of Frobisher Bay and Cumberland Sound the coasts are low and hilly with many gently sloping beaches and large tidal flats of sand and mud (Fig. 4). Near the mouths of these two inlets the coast is indented by fiords with steep rocky shores (Fig. 5). On sandy beaches and rocky shores south of the transition the fauna was similar throughout. North of the transition the shore were mainly steep and rocky, and gently sloping beaches were rare, but even where conditions were suitable for intertidal fauna, life was generally absent (Fig. 6).

Stephenson and Stephenson (1954) have described the effects of ice action upon the shore fauna. In Baffin Island ice forming close to the shores

eventually reaches six or seven feet and may become even thicker if there is much ice movement during the winter. If the thickness of the sea ice is greater than the tidal amplitude, as is common in many parts of the arctic, the entire shore becomes completely covered with ice. However, when the tidal amplitude is large, as in southern Baffin Island[1] only the upper reaches of the shore freeze solidly, forming an ice foot (Fig. 7). The ice foot is more conspicuous on steep rocky shores than on gently sloping beaches. At low water during winter, ice floating on the surface of the sea close to shore abrades the exposed surfaces below the ice foot. Thus ice on the shore affects the intertidal fauna in two ways. Animals present at the upper levels are generally killed by freezing, and at lower levels they are abraded from the exposed surfaces (Fig. 8). Both freezing and abrasion occur extensively in Cumberland Sound and Frobisher Bay. North of Padloping Island the intertidal zone appeared to freeze almost completely, and abrasion was relatively unimportant. At Padloping Island the entrance to a tidal lagoon was reported by the Eskimo to be comparatively free of ice in winter, and a few intertidal animals were found there (Station A44).

North of Padloping Island the sea-bottom was barren when seen through shallow water, although it was beyond the reach of abrading ice. Thorson (1933, p. 17) suggested that such a barren zone extending from the shore into shallow water was created mainly by a layer of surface water of very low salinity formed during the summer thaw. He called this layer the "fjord-water". Bertelsen (1937, p. 15) named the combined shore and shallow water barren zone the "euryhaline littoral fauna" zone. Most of the species collected in Baffin Island in 1953 are panarctic shallow-water animals that occur only incidentally on the shores. These animals are not found near high water level, where they would be exposed for long periods to air, and they keep below the surface layer of low salinity "fjord-water" wherever it occurs. Thus a barren "euryhaline littoral fauna" zone is formed. This zone was clearly visible north of Padloping Island but was not seen in Cumberland Sound or Frobisher Bay. The specifically intertidal animals such as the periwinkle, *L. saxatilis*, and the barnacle, *B. balanoides*, are found in places where there is a well-developed "euryhaline littoral fauna" zone (Bertelsen, 1937, p. 27). Consequently these species are not kept off the shores by "fjord-water" as are the shallow-water species, and the presence of "fjord-water" is not the limiting factor in the distribution of these two species. The distribution of the lug-worm, *A. marina* may be similar, for it is found at Angmagssalik and Pangnirtung but it has not been found north of the transition in either Greenland or Baffin Island. Tolerance of variable salinity is a typical adaptation of intertidal animals and may account for the presence of *B. balanoides*, *L. saxatilis*, and *A. marina* at Angmagssalik in east Greenland where there is a well-developed layer of "fjord-water".

[1]At Pangnirtung the tidal amplitude varies between sixteen and twenty feet and in Frobisher Bay, between twenty and forty feet. At Padloping Island the neap tide amplitude is about two feet, and the spring tide amplitude about six feet. North of Padloping Island the tidal ranges are not so well known, but appear to be similar to those at Padloping Island (Canada: Hydrog. Service, 1953).

Fig. 6. Near Clyde settlement, Station A51. Low water exposes small tidal flats devoid of life.

Fig. 7. The ice foot in Frobisher Bay. Low water occasionally revealed an ice foot 25 feet thick.

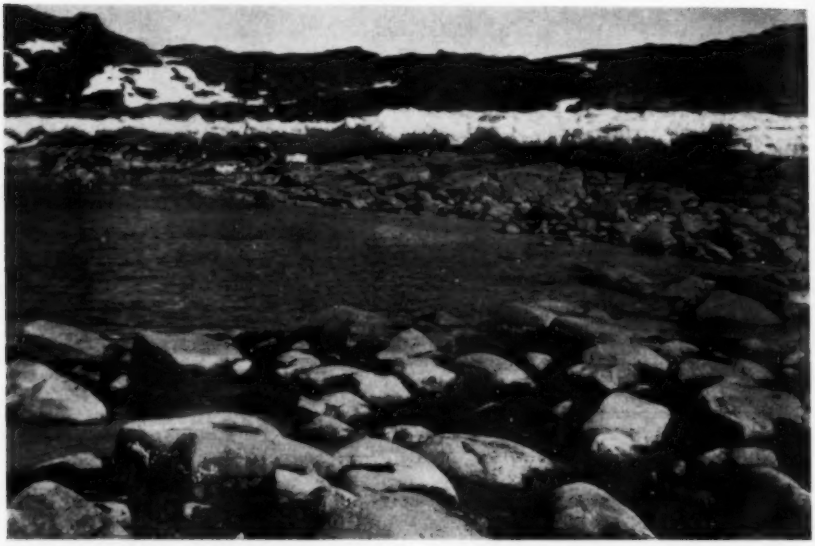

Fig. 8. Beach in Frobisher Bay, Station A8, with 35-foot tidal range. The algae and barnacles in the foreground are kept off the upper parts of the boulders by ice action. Some ice is still stranded on the upper levels of the beach.

The unpublished oceanographic data on sea temperature and salinity from the *Calanus* expeditions to Frobisher Bay and Cumberland Sound suggest that these regions may be influenced by the warm currents flowing west from Greenland (Canada. Fish. Res. Bd., 1953), unlike the sea-water farther north. The northern limits of *B. balanoides*, *L. saxatilis* and *A. marina* occur at Upernavik and Angmagssalik in west and east Greenland, where the influence of Atlantic water has been demonstrated. Recent collections from Baffin Island indicate that the northern limits of these species on the east coast may coincide with the northern limits of non-polar water.

The distribution of specifically intertidal animals in southeast Baffin Island may reflect a change in the nature of the sea-water related to the underlying currents. If this is so, Madsen's hypothesis that the intertidal population is influenced by the currents, will be valid for the east Baffin Island coast. It thus seems that the marine arctic and subarctic regions in Baffin Island and Greenland differ in their intertidal populations. In the subarctic region there are marine animals specifically adapted to living on the shores; these species do not extend into the arctic region. In places protected from ice action the subarctic shores in Baffin Island support a fauna and flora. The arctic shores, however, are almost barren because ice covers almost the whole intertidal region during winter; a surface layer of very low salinity water presumed to occur in summer prevents the shallow-water pan-arctic species from settling on the shore; and pure polar water prevents the northward distribution of the

specifically intertidal species. North of Cumberland Sound the three factors come into operation simultaneously. They do not do so in east Greenland, for the specifically intertidal species are found at Angmagssalik, where the shallow-water species are kept below the surface layer of "fjord-water". Madsen reports that the tidal range does not vary much along the east Greenland coast, and cannot therefore be responsible for limiting the northward distribution of the intertidal species. The tidal amplitude alone means very little. It is the relationship between the depth of ice formed in winter, the extent of the "fjord-water" layer, and the tidal amplitude that is important. Where the shore is partly unaffected by ice and bathed in water of sufficiently constant salinity, the panarctic species will populate the shores regardless of whether they are in the arctic or subarctic regions. They can rarely do so in the arctic region because of the low tidal amplitude and the extensive development of "fjord-water".

It is, therefore, clear that there are two intertidal transitions, one which affects the panarctic shallow-water species, and the other the specifically intertidal species. The two transitions coincide in Baffin Island; they do not coincide in east Greenland. Once the panarctic species that are limited vertically by ice and low salinity are recognized, the northern limit of the subarctic in Baffin Island appears to coincide with the northern limit of the specifically intertidal species.

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NEAR SURFACE SOIL TEMPERATURE MEASUREMENTS AT RESOLUTE BAY, NORTHWEST TERRITORIES

Frank A. Cook*

DURING the four summers of 1950–3 diamond drilling operations were undertaken at Resolute Bay, Cornwallis Island, for the purpose of installing temperature measuring equipment in the permanently frozen ground. Several recent papers have discussed various aspects of the project. Bremner (1955) described the actual drilling, analysed the difficulties encountered and made several recommendations based on that analysis for the possible assistance of others meeting similar drilling problems. Misener (1955) reported on heat flow in the crust basing his work on deep hole readings and on the examination of the thermal properties of core samples recovered at varying depths. Misener, Bremner and Hodgson (1956) discussing the operation in general terms, combined information given by Bremner and Misener. However, apart from the general observations of Thomson and Bremner (1952), little of the temperature data itself has been reported upon.

The present paper considers the near surface soil temperature data proper, and is based upon daily routine readings taken by officers of the Meteorological Division of the Canadian Department of Transport and the Dominion Observatory of the Department of Mines and Technical Surveys. The data have been supplemented by special studies undertaken by the writer during the three summers of 1953–5 and the winter of 1953–4. So little soil temperature data are available from permafrost regions in North America that the data are published now, without waiting for the more conventional long-term averages.

The first part of the paper is concerned with routine near surface soil temperature readings from within the 6-foot overburden of frozen gravel and shattered rock overlying the limestone bedrock. This depth is subject to daily fluctuations in temperature resulting from variations in surface weather above the soil. Monthly averages for the period 1951–5 are given for depths at 4, 8, 18, and 60 inches, and the five year averages shown. At other depths, where recording elements have been installed more recently, that is, at depths of 10, 20, 25, and 35 inches, data for the two years 1954–5 have been considered. The second part of the paper is a preliminary report on a special study made in the fall of 1955 on the freeze-back in the active layer. Generalizations on soil temperature and moisture content and migration are presented based on field data. Detailed studies of the interrelationships of climate and soil with the thermal regime will be published later.

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Photo: Guy Drouin

Fig. 1. Cable installation showing thermistors at 4, 8, 18, and 60 inches.

Equipment

The installation was made in the vicinity of the former site of the joint Canadian-United States weather station some 1,000 feet inland from Resolute Bay, and on a prominent raised beach line. Here shattered rock and gravel overlie the limestone bedrock to a depth of approximately 6 feet. Many cables were installed in the course of diamond drilling operations (Bremner, 1955), but this paper is limited to the results from two cables, each with attached ceramic resistance thermometers.

The first cable, with thermometers at depths of 4, 8, 18, 39, and 60 inches below the surface, was installed during the summer of 1950 (Fig. 1). Daily readings are available from October of that year, except at the 39-inch level where readings were discontinued from June 1952 and for certain winter readings on the thermometer at the 4-inch depth, when resistance values were outside calibration curves. The second cable was installed in 1953, and readings from thermometers at depths of 10, 20, 25, and 35 inches below the surface are available from September. Both cables have sufficient lead-in to carry them to a heated building about 100 feet south of the area, where the recording equipment is installed. Individual elements on the first cable have been calibrated to a MSC Thermometer Indicator Type C2 and conversion tables prepared from microamperes to degrees Fahrenheit. Elements on the other cable have been calibrated to a standard Wheatstone bridge and conversion tables from resistance in ohms to temperature in degrees Fahrenheit prepared. While readings from the two cables do not fit exactly into the same curve, as they are placed 225 feet apart in overburden of a slightly

different composition with resulting slight differences in temperature, for the purpose of this paper they are combined, as all characteristics are similar.

For the special freeze-back study additional thermistors were installed in 1955 at depths of 2, 5, 8, 11, 14, 17, and 20 inches below the surface. These thermistors were made to specifications by Industrial Instruments Inc., and calibrated separately to a standard Wheatstone bridge. On the average they offered 225 ohms resistance at 40°F and 440 ohms at 15°F, the extremes of temperatures recorded during the test. Lead-in wires were run to the heated building housing the permanent equipment, and all measurements taken there, eliminating the many problems connected with the use of a temperature-sensitive bridge in below freezing weather.

Part I. Near Surface Soil Temperatures

Data discussed includes daily, monthly, and yearly averages, and the influence of solar insolation, air temperature, and precipitation.

Daily fluctuations

Minor daily fluctuations can be seen in the active layer (Fig. 2), decreasing in amplitude with depth, until below the permafrost table at approximately 25 inches they are barely perceptible, disappearing completely at a depth of 60 inches.

The amplitude of the daily variation changes with the season of the year, achieving maximum range in summer. However, summer diurnal variation is much less than in non-permafrost regions to the south. This is due to the

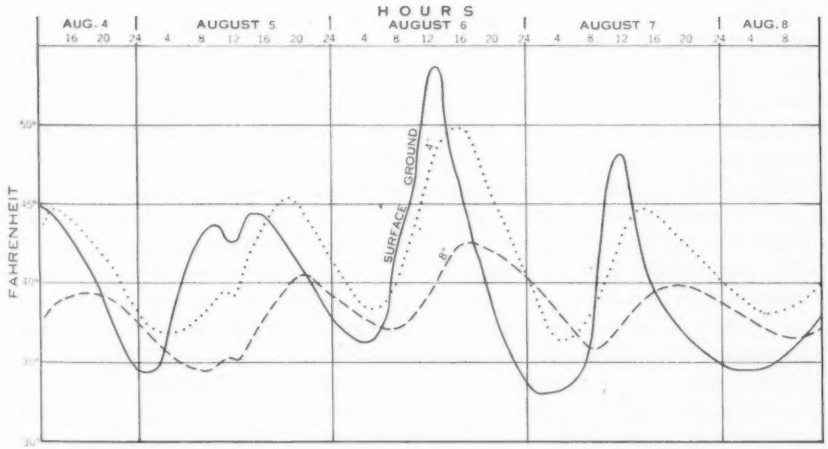

Fig. 2. Daily fluctuations in near surface ground temperature, 5–7 August 1955.

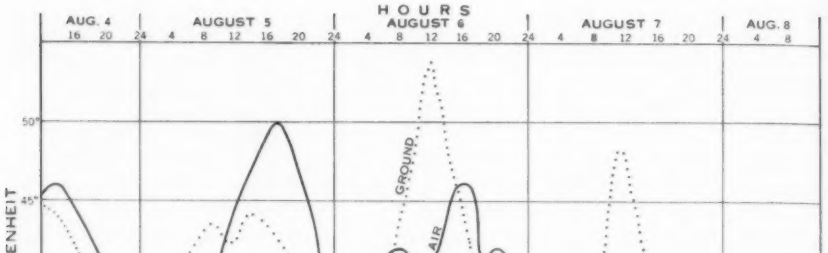

Fig. 3. Effect of insolation on surface ground temperature, 5–7 August 1955.

greater uniformity of the mean surface air temperature, resulting from continuous daylight and the relatively weak circulation prevailing at this time of year. While the maximum air temperature may occur at any time within the 24-hour period, interrupting the diurnal rise and fall found in temperate regions, the soil temperature generally reaches an early afternoon maximum; the greatest daily fluctuation in soil temperature appears to be related to the intensity of solar radiation and the continuous sunshine rather than air temperature. Several hours of sunshine, with heavy absorption of solar energy will raise the soil temperature in the top few inches of the ground appreciably higher in absolute value than the surface air temperature above the ground. This condition is shown in Figure 3 based on hourly readings for the period August 5–7, 1955. The extreme maximum air temperature for the year was recorded on August 5, a cloudy day during which surface air temperature exceeded the temperature on the surface of the ground and at all soil levels measured beneath. The next day, however, was clear and sunny, and solar radiation raised surface ground temperature, and that recorded at 4 inches below the surface, well above the maximum surface air temperature for the day.

The daily fluctuations in temperature at the ground surface level are reflected in the soil below, with a certain lag, and there is a damping of the wave with depth. Figure 2, based on data for the same period as Figure 3, illustrates these features.

In the fall, as periods of darkness lengthen each day, fluctuations in soil temperature follow surface air temperature with a daily maximum and a nightly minimum. As the season progresses and the soil freezes solidly and a cover of snow forms, variations in surface air temperature become less and less effective; during winter and continuous darkness there is little variation in soil temperature, and any fluctuation tends to be the result of an unusually

low minimum temperature, rather than the influence of surface maximum air temperature. As in summer, there is great uniformity in the mean surface air temperature, and either maximum or minimum temperature may occur at any time within the 24 hours. In the spring, with return of day and lengthening periods of light, daily fluctuations again follow surface air temperature, until the season has progressed sufficiently for incoming solar radiation to be effective.

The temperature curve for the year plotted from daily averages shows the following characteristics; the warm up in spring is gradual until June, when in response to increasingly high surface temperatures and increased incoming radiation, the rate increases. Maximum daily fluctuations are observed in July and August. In late August, when daily surface air temperatures fall below freezing, there follows a rapid decline in all values until the soil temperature reaches the freezing point. Here it remains for a period of time as the chilling of the ground is temporarily compensated by latent heat of fusion given off by the ground-water until it has turned to ice. This break in the slope of the curve along the 32°F line has been called by Sumgin the "zero curtain" (Muller, 1947, p. 17), it is discussed more fully in the second part of this paper. Table 1 shows that while the "zero curtain" lasts for a

Table 1. Active layer zero curtain at Resolute Bay, 1951–5.

Depth in inches	*Duration in days*				
	1951	*1952*	*1953*	*1954*	*1955*
4	–	–	–	–	–
8	21	12	10	12	11
10	NR[1]	NR	12	16	12
18	30	23	17	19	15
20	NR	NR	19	23	16

[1] NR–No record.

very short period of time at 4 inches below the surface, it can exist for more than three weeks just above the permafrost table. With the advance of winter there is a gradual decrease in soil temperatures until the winter low is reached, at which point the cycle starts again.

Monthly averages

The mean monthly temperatures in the ground for the period 1951–5, as shown in Table 2, indicate that in the active layer, at depths of 4, 8, 10, and 18 inches below the surface, the minimum temperature occurs in February, the same month in which minimum air temperature is recorded. At depths of 20, 25, and 35 inches it occurs in March, giving a lag of one month. The minimum temperature at 60 inches is recorded in April, showing a lag of two months at this depth. The maximum temperature at 4 and 8 inches occurs in July, as does the maximum air temperature at the surface. One month lag is noted at depths of 10, 18, 20, and 25 inches, while at 35 and 60 inches below the surface the maximum occurs in September, two months after the maximum air temperature is attained. Only two months, July and August, show a mean monthly temperature above freezing in the active layer.

The range of mean monthly temperatures decreases with depth; in 1954 it was 56.3°F at 8 inches, 49.4° at 18 inches, 40.2° at 25 inches, and 37.2° at 60 inches.

Figure 4 shows that there is a spring and fall overturn to depths below 60 inches. In January the coldest temperature is at the top, the ground warming progressively with depth. In 1954, the January mean temperature at 8 inches

Table 2. Monthly and yearly averages of near surface soil temperatures, 1951–5.

Year	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Year*
						4 inches							
1951	−16.4	−20.4	−17.9	−10.5	3.7	28.6	44.1	37.5	30.3	12.5	−9.5	−19.8	5.2
1952	−21.0	−27.7	−24.3	−11.5	14.5	45.6	44.2	44.3	26.8	14.1	3.6	−3.7	8.7
1953				−2.5	5.9	17.4	40.2	38.8	30.3	13.9	−1.5	−10.2	
1954				−12.7	2.9	22.8	42.6	41.7	31.5	16.1	2.4	−6.8	
1955	−11.5	−17.3	−16.2	−10.5	1.4	23.1	39.0	37.4	28.7	19.5	0.2	−10.3	7.0
1951–55 Av.				−9.5	5.7	27.5	42.0	39.9	29.5	15.2	−2.4	−10.2	
						8 inches							
1951	−14.4	−18.2	−17.0	−10.8	2.7	24.3	37.2	34.6	29.2	13.4	−7.8	−21.2	4.3
1952	−24.0	−25.2	−23.1	−11.0	11.5	37.2	38.3	35.2	26.2	14.5	4.6	−4.6	6.6
1953	−16.7	−17.5	−16.4	−3.9	9.5	15.9	35.4	35.1	29.2	15.2	−4.1	−9.3	6.1
1954	−15.6	−20.0	−17.4	−13.0	1.3	19.1	37.4	36.9	31.0	16.8	2.9	−6.3	6.1
1955	−11.6	−18.4	−17.1	−10.9	0.4	19.9	36.1	34.4	28.5	19.2	0.9	−9.5	6.0
1951–55 Av.	−16.5	−19.9	−18.2	−9.9	5.1	23.3	36.9	35.2	28.8	15.8	−0.8	−10.2	5.8
						10 inches							
1954	−14.2	−15.3	−14.0	−10.9	1.8	17.0	33.7	35.4	30.4	15.4	−0.2	−6.0	6.1
1955	−10.6	−18.8	−18.9	−11.3	−0.6	17.8	32.3	33.3	27.7	19.1	0.9	−5.7	5.4
						18 inches							
1951	−10.9	−15.4	−15.2	−10.1	1.1	20.0	32.5	32.6	29.9	16.5	−2.6	−15.3	5.2
1952	−19.7	−21.9	−22.1	−12.6	7.6	26.2	33.8	32.8	27.9	16.5	6.6	−1.1	6.2
1953	−10.5	−12.3	−14.7	−4.4	3.8	13.2	29.2	32.9	31.5	16.9	2.8	−5.2	7.0
1954	−11.8	−15.4	−15.0	−12.1	0.0	15.7	32.7	34.0	31.7	18.8	6.2	−2.3	6.9
1955	−7.7	−14.1	−14.9	−10.1	0.8	16.0	32.1	33.1	29.9	20.3	1.8	−6.2	6.7
1951–55 Av.	−12.1	−15.8	−16.4	−9.9	2.7	18.2	31.7	32.9	30.2	17.8	3.0	−6.0	6.4
						20 inches							
1954	−7.5	−9.5	−10.2	−9.4	−1.0	13.6	32.5	34.1	31.5	18.7	7.2	1.5	8.5
1955	−3.0	−8.9	−9.2	−6.9	−1.1	12.8	30.9	32.7	29.1	20.3	11.2	2.7	9.2
						25 inches							
1954	−5.7	−8.1	−8.8	−8.2	−1.5	11.4	29.8	31.7	31.3	21.0	13.0	5.8	9.3
1955	0.1	−5.7	−7.3	−6.0	−0.9	11.6	28.8	31.3	28.8	21.3	13.7	4.3	10.0
						35 inches							
1954	−4.4	−6.9	−7.9	−7.8	−1.8	9.2	26.7	30.0	30.3	21.7	13.9	7.0	9.2
1955	1.3	−4.4	−6.4	−5.6	−1.1	9.4	25.9	29.7	28.3	21.5	14.8	5.6	10.7
						60 inches							
1951	−3.7	−8.7	−10.9	−8.1	−2.3	8.7	20.0	25.5	26.7	20.2	7.0	−5.1	5.8
1952	−12.2	−13.9	−15.9	−13.2	−4.1	15.3	24.1	26.6	26.3	19.0	11.8	3.3	5.6
1953	−3.6	−8.3	−9.6	−5.0	−1.2	7.4	19.9	25.8	26.8	20.4	10.5	3.3	7.2
1954	−3.9	−7.6	−9.3	−9.5	−2.9	6.3	22.9	26.2	27.7	22.0	12.6	5.8	7.5
1955	−0.3	−5.7	−8.9	−7.5	−2.2	7.1	21.6	26.4	27.1	21.7	13.3	2.2	7.9
1951–55 Av.	−4.7	−8.8	−10.9	−8.7	−2.5	9.0	21.7	26.1	26.9	20.7	11.0	1.9	6.8

was -15.5°F, -14.2° at 10 inches, -11.8° at 18 inches, -7.4° at 20 inches, -5.7° at 25 inches, -4.0° at 35 inches, and -3.9°F at 60 inches below the surface. In summer the reverse is true, the warmest temperature is at the surface, the ground cooling progressively with depth. In 1954, the July mean temperature at 4 inches was 42.6°F, 37.4° at 8 inches, 33.7° at 10 inches, 32.7° at 18 inches, 32.5° at 20 inches, 29.8° at 25 inches, 26.7° at 35 inches, and 22.9°F at a depth of 60 inches.

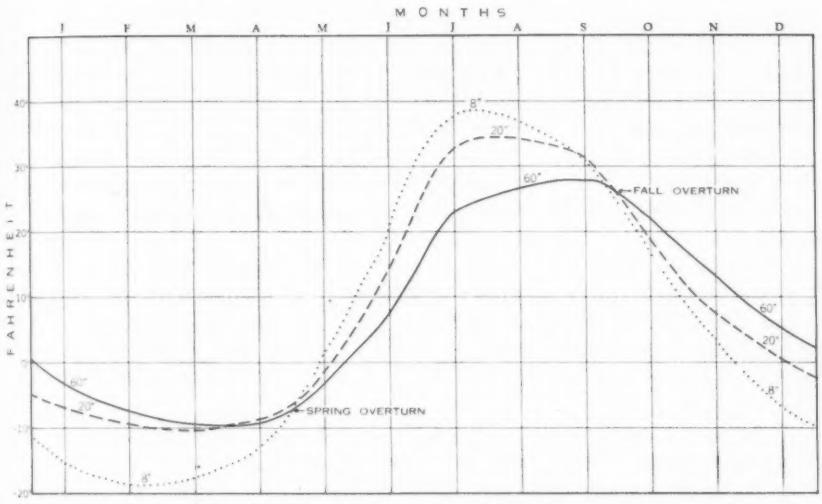

Fig. 4. Spring and fall overturn to depths of 8, 20, and 60 inches, 1954.

The mean annual soil temperature increases from the surface to the permafrost table, where it starts to decrease again. The mean annual surface temperature for 1954 was 3.1°F, increasing to 6.1° at 8 inches, 6.9° at 18 inches, 8.5° at 20 inches, and 9.3°F at 25 inches, the approximate level of the permafrost table. Below this level it decreased to 9.2°F at 35 inches and to 7.5° at 60 inches below the surface.

Precipitation

The effect of rainfall seems negligible; it adds little to the moisture content of the soil, a factor affecting soil temperature. Normally rainfall only dampens the actual ground surface, the moisture content of the soil being derived from melting permafrost within the soil itself. The average annual rainfall, falling in July, August and September, is less than 3 inches, with individual showers being light and of low intensity. In 1954, 16 days of measurable rain gave the year's total liquid precipitation of 2.71 inches. Of this total, 12 days gave less than 0.2 inches each, while one day, August 29, gave 0.97 inches, or one-third the total for the year.

While the total annual snowfall is also light, averaging about 25 inches, it does have the effect of decreasing any variation due to fluctuations in surface air temperature. Some snow cover is present from about the beginning of September to the end of May; it is not possible to give depths at any one time because the snow is constantly moving, being blown about almost continuously. No regular measurements have been taken at the time of routine readings.

No routine measurements of soil-water in the active layer, or of the height of the water table were taken.

Part II. Freeze-back in the Active Layer, 1955

A knowledge of the thermal regime of the active layer in permafrost is basic to an understanding of many problems in the study of periglacial phenomena. This is especially true for the study of patterned ground, as the majority of hypotheses relating to its development are built around the action of frost in the soil.

Of special interest is the manner in which the freeze-back occurs in the fall; it is considered by many to be the most important part of the freeze-thaw cycle. It is a phase, however, on which there is practically no quantitative field data. Throughout the summer and fall of 1955 the writer studied the thermal regime in the active layer at Resolute Bay in an integral soil temperature–soil analysis–climatic data study. During August and September a special study was conducted on the freeze-back and this part of the present paper is a preliminary presentation of some generalizations based on field data for that period.

Use of the permanent installation in shattered rock and gravel, combined with an additional vertical section installed in a nearby pocket of clay in which several immature stone polygons were developing, allowed the recording of temperature gradients in two different materials. This is of great significance in patterned ground study where differential freezing and pressures play so important a part.

Measurements

Readings were taken at four-hourly intervals for the period August 28–October 1, this time interval providing sufficient data to give a complete picture of soil temperatures during the freeze-back period.

The start of the freeze-back, August 28, coincided with the drop of the daily maximum air temperature below the freezing point. At Resolute Bay once the daily maximum air temperature falls below freezing it continues to drop steadily each day, and does not rise again that season. An examination of existing records reveals that this has occurred each year since the establishment of the weather station in 1947.

Before August 28 there were daily fluctuations in temperature in both the shattered rock and the clay pocket, the wave being damped and subjected to a lag with depth. The shattered rock and gravel showed a greater wave amplitude than the clay owing to its greater conductivity. Once the soil temperature reached freezing point, daily fluctuations ceased for the period of the zero curtain, the period of time necessary for the turning of the water content into ice. After the soil became solidly frozen daily fluctuations started again, but with smaller amplitudes than previously, due to the lateness of the season and the presence of a light snow cover. Fluctuations ceased when the snow cover in the area reached a depth of 6–8 inches.

Zero curtain

The data shows the condition called by Sumgin "the zero curtain" (Muller, 1947, p. 17). As already stated the lowering of temperature in moist

ground does not proceed at a uniform rate, as the penetration of cold is retarded by the moisture content of the soil. The loss of heat is temporarily compensated by latent heat of fusion given off until all water is turned to ice. This is aided by the hydrostatic pressure developing in the unfrozen material which lowers the freezing point of the soil. The hydrostatic pressure develops due to downward squeezing between the advancing frost line and the permafrost table, and to the increase in volume of the moisture as the temperature of the water itself is lowered. The maximum zero curtain occurs

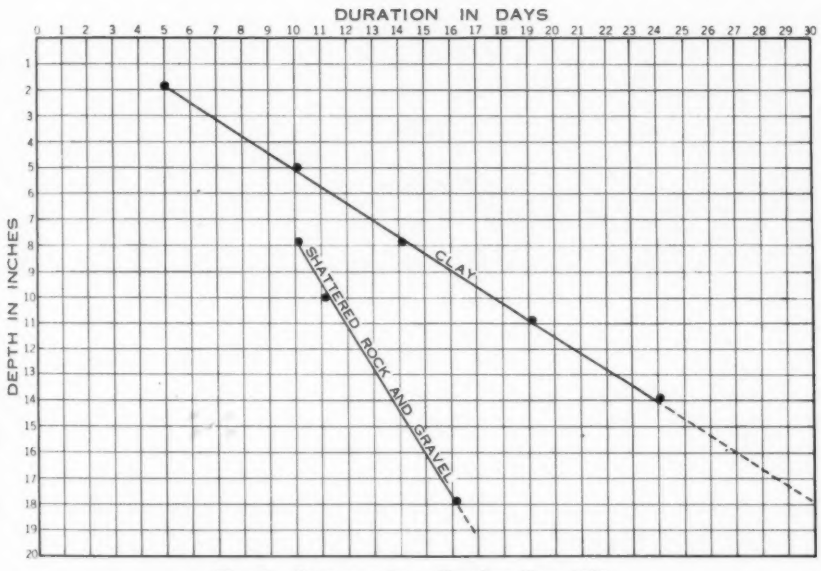

Fig. 5. Zero curtain at Resolute Bay, 1955.

just above the permafrost table where the water is unable to escape. The depth and duration of the zero curtain is controlled by several factors such as available moisture, the thermal properties of the soil, and weather conditions.

Figure 5 shows the zero curtain in both the shattered rock and gravel and the clay for 1955. The clay shows a longer zero curtain than the shattered rock and gravel, partly due to its greater moisture content. At 8 inches in the shattered rock and gravel the zero curtain effect lasted 10 days, while in the clay at the same depth it was prolonged to 14 days. At 15 inches a 14-day zero curtain in the shattered rock and gravel was prolonged to 25 days in the clay. The interval between the zero curtain at equivalent depths increased with depth to the permafrost table. The implications to patterned ground study of this differential freezing with associated pressures are important and will be discussed in a later paper.

Date	Depth	Clay 2"	5"	8"	11"	14"	17"	20"	Shattered rock and gravel Sfc.	4"	8"	10"	18"	20"	25"	35"	Surface air °F. daily Max.	Min.
Aug. 28		32.6	32.7	32.2	32.2	32.1	32.1	32.1	32.5	33.6	32.6	32.2	32.2	32.2	31.6	30.0	34.0	32.2
29		33.9	33.5	32.8	32.4	32.3	32.2	32.1	33.6	33.5	33.4	32.6	32.4	32.5	31.4	30.1	35.5	32.2
30		32.4	32.7	32.4	32.4	32.4	32.2	32.1	31.8	33.2	32.6	32.5	32.5	32.3	31.4	30.0	33.6	30.2
31		31.4	31.6	31.7	31.7	31.8	31.8	31.9	31.3	32.4	31.9	31.8	31.8	31.8	31.3	30.0	31.5	28.9
Sept. 1		31.3	31.4	31.5	31.5	31.5	31.6	31.7	31.3	32.5	31.9	31.8	31.8	31.7	31.3	30.0	31.4	28.6
2		31.2	31.3	31.4	31.4	31.5	31.6	31.7	31.2	32.3	31.5	31.8	31.5	31.6	31.3	30.0	31.7	28.0
3		31.2	31.3	31.4	31.4	31.5	31.6	31.7	30.4	32.5	31.9	31.7	31.8	31.6	31.3	30.0	30.8	25.7
4		31.1	31.3	31.4	31.4	31.5	31.6	31.7	30.7	32.4	31.9	31.7	31.9	31.6	31.3	30.0	28.6	25.2
5		30.4	31.2	31.4	31.4	31.5	31.6	31.7	29.5	32.2	31.7	31.7	31.7	31.6	31.3	30.0	28.4	21.9
6		30.4	31.1	31.4	31.4	31.5	31.6	31.7	30.5	32.2	31.8	31.7	31.7	31.7	31.2	30.0	29.1	25.0
7		30.6	31.0	31.3	31.4	31.5	31.6	31.7	31.3	32.4	31.8	31.6	31.8	31.7	31.2	30.0	30.1	26.4
8		30.6	31.0	31.3	31.3	31.4	31.5	31.7	31.0	32.3	31.6	31.6	31.6	31.6	31.1	30.0	32.0	24.7
9		30.6	31.0	31.2	31.3	31.4	31.5	31.6	29.5	32.3	31.6	31.5	31.6	31.6	31.1	29.9	31.2	25.0
10		30.3	30.8	31.2	31.3	31.4	31.5	31.6	28.4	31.7	31.6	31.3	31.8	31.6	31.1	29.8	27.2	17.9
11		30.1	30.6	31.1	31.3	31.4	31.5	31.6	28.3	31.0	30.8	30.6	31.5	31.6	30.9	29.8	25.8	20.0
12		29.8	30.4	31.1	31.2	31.4	31.4	31.6	28.9	30.3	30.0	29.5	31.5	31.6	30.8	29.7	23.8	20.0
13		29.2	30.0	31.0	31.2	31.4	31.4	31.6	26.9	29.4	29.4	28.6	31.4	31.5	30.7	29.7	25.3	19.6
14		28.6	29.5	30.7	31.2	31.4	31.4	31.6	26.0	28.2	28.9	27.4	31.3	31.2	30.2	29.3	25.0	14.7
15		27.5	28.7	30.2	31.2	31.4	31.4	31.6	25.8	26.8	27.9	26.1	31.2	30.5	29.4	28.8	22.9	11.3
16		28.8	29.3	30.2	31.1	31.4	31.4	31.6	27.8	28.5	28.4	26.0	30.7	29.7	28.7	28.4	27.4	19.4
17		29.3	29.7	30.3	31.0	31.4	31.4	31.6	29.0	29.4	28.9	26.4	30.4	29.0	28.3	28.0	28.6	22.1
18		30.0	30.2	30.5	31.0	31.4	31.4	31.5	30.2	30.5	29.7	27.0	30.3	28.8	28.2	27.9	31.4	21.5
19		29.9	30.2	30.6	31.0	31.4	31.4	31.5	29.4	30.1	29.5	27.3	30.1	28.6	28.2	27.9	29.9	23.8
20		29.8	30.3	30.6	30.9	31.3	31.4	31.5	28.8	29.9	29.4	27.4	29.9	28.4	28.0	27.5	30.4	22.0
21		29.7	30.0	30.4	30.9	31.2	31.4	31.4	27.9	28.5	28.0	26.6	29.5	27.9	27.6	27.3	24.7	16.9
22		29.9	30.2	30.5	30.8	31.2	31.3	31.3	28.5	28.6	27.8	26.3	29.0	27.4	27.3	27.0	25.4	22.6
23		29.3	29.8	30.4	30.8	31.1	31.3	31.3	25.6	25.9	26.0	25.1	28.5	26.9	26.9	26.6	22.2	14.1
24		29.6	29.8	30.1	30.6	31.0	31.1	31.2	27.5	26.1	25.4	24.3	27.6	26.0	26.2	26.1	19.9	14.0
25		28.1	29.6	30.0	30.5	30.8	31.0	31.0	26.1	25.9	25.2	24.5	27.0	25.7	25.9	25.9	24.7	19.8
26		28.6	29.1	29.3	30.2	30.6	30.8	30.8	25.7	25.1	24.5	24.0	26.4	25.3	25.5	25.6	24.1	18.2

Table 3. Daily averages of soil temperatures for period of freeze-back, 1955.

Pe

Fig

Photo: Guy Drouin

Fig. 6. Excavation in frozen clay, September 12, showing segregation and growth of ice lenses.

Penetration of the 32°F freezing line

Table 3 shows that the 32°F line proceeded downward from the surface as most of the heat was lost to the atmosphere through conduction and radiation. Latterly the permafrost table advanced upward, as trapped heat was lost into the permafrost below.

The 32°F temperature line advanced more quickly in the shattered rock and gravel than in the clay. Excavation to the permafrost table was attempted weekly and notes taken on the condition of the soils. On September 5 the clay had frozen to a depth of 2½ inches, while the shattered rock and gravel had frozen solidly to a depth of 4 inches. At this time ice was also appearing on nearby freshwater lakes and the permafrost table had risen ¾ inch. On September 12 the clay was solidly frozen to a depth of 5 inches and in the top 3 inches ice lenses were beginning to form and there were stratified layers of clay and clear ice approximately 0.04 inches in depth. The permafrost table had advanced upward by one inch, and the enclosed material in the unfrozen clay pocket looked and felt mealy in texture. The shattered rock and gravel was frozen to a depth of 12 inches, and although no lenses had formed in this material, some of the individual particles were encased in ice. By September 19, the last day on which it was possible to excavate, the clay was solidly frozen down to 10 inches, with considerable ice segregation in the top 6 inches, ice lenses of clear ice being between 0.04 and 0.08 inches in depth, as shown in Figure 6. The permafrost table had advanced upward to 20 inches below the surface, and the shattered rock and gravel was frozen solidly.

No heaving of the surface of the clay was apparent to the eye, but precise instrumental measurements were not taken. However, as Haley and Kaplar have shown (1952, pp. 264–5), heaving may be negligible when reduction in the volume of soil below is equal to volume of water removed, because sufficient tensile force develops in the pore water in the process of ice segregation to consolidate the soil.

Table 4. Percentage moisture content of soil during freeze-back, 1955.

	Clay					*Shattered rock and gravel*				
Depth in inches	*Date* *Aug. 22*	*Aug. 29*	*Sept. 5*	*Sept. 12*	*Sept. 19*	*Aug. 22*	*Aug. 29*	*Sept. 5*	*Sept. 12*	*Sept. 19*
3	16	17	24	32	34	9	9	10	11	11
6	15	15	18	23	25	8	8	9	10	10
9	14	15	15	12	18	8	8	7	8	9
12	14	14	14	12	14	8	8	7	6	7
18	15	15	12	8	7	8	8	7	6	6
24	17	17	18	18	18	8	8	7	6	6
Average	15.1	15.5	16.7	16.7	16.9	8.1	8.1	7.8	7.8	8.1

Moisture content and migration

During the weekly excavations samples of soil were taken for the purpose of studying moisture content by dry weight. Sampling was done at 3 inch intervals to a depth of 12 inches, and at 18 and 24 inches, the latter depth being approximately the permafrost table. The samples were oven-dried to remove moisture. On August 29, as shown in Table 4, the profile from surface to the permafrost table revealed that the moisture content was distributed rather evenly throughout the soil, although slightly higher percentages were noted at both the ground surface and at the actual permafrost table. The shattered rock and gravel averaged 8.1 per cent moisture content by dry weight, while the clay averaged 15.5 per cent. The difference in moisture content was caused by the difference in particle size, the fine-particled clay being able to retain considerably more water than the coarse-particled gravel.

On September 5 the moisture content of the clay in the top 3 inches had increased by 50 per cent, while that of shattered rock and gravel showed little change. This situation was intensified on September 12, when moisture content in the top 3 inches of clay stood 100 per cent above the amount recorded before freezing began, and considerable increases were noted at 6 and 9 inches as the freezing isotherm progressed downward. Again the shattered rock and gravel showed little change. On September 19 there was a further slight increase in moisture content of the clay in the top layers.

Thus the data show considerable moisture migration in the clay pocket, and little moisture migration in the shattered rock and gravel. The different behaviour appears to be related to differences in structure between the two soils, coarse-grained soils being unable to draw and hold water, while the fine-grained soil can not only hold greater amounts of moisture, but can also draw moisture from great distances. As Taber has shown (1929; 1930) in the laboratory, freezing of the ground in the clay pocket proceeded in the early stages as in an open system, moisture migrating upward to be available to the ice lenses forming parallel to the freezing surface. The moisture content of

the lower layers was reduced accordingly. In the latter stage, freezing probably proceeded as in a closed system, with both the downward freezing surface and the advancing permafrost table attracting some moisture.

The writer wishes to acknowledge the manual assistance given by individual members of the staff of the Ionosphere Station of the Telecommunications Division of the Canadian Department of Transport, as well as laboratory, work-shop and congenial living accommodation made available at that station. He is indebted to the staff of Resolute Bay joint Canadian-U.S. weather station for their enthusiastic support in supplying climatic data and equipment as requested, and to Mr. Andrew Thomson of the Meteorological Division of the Canadian Department of Transport for permission to use the routine soil temperature data. The Royal Canadian Air Force supplied air transportation to and from Resolute Bay on several occasions. The writer is grateful for the continuing interest in the project of Dr. John Hodgson of the Dominion Observatory; to Professor J. Ross Mackay of the University of British Columbia for invaluable advice in the earlier stages of his research; and to Professor J. Brian Bird of McGill University under whose direction the field project of 1955 was conducted. Finally, he is indebted to the McGill University-Arctic Institute-Carnegie Program for a grant covering field work for the summer of 1955.

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REVIEWS

CHANGING LAPPS: A STUDY IN CULTURE RELATIONS IN NORTHERNMOST NORWAY

By Gutorm Gjessing. *London: London School of Economics and Political Science, Dept. of Anthropology, and Copenhagen: Munksgaard, 1954. (Monographs on Social Anthropology No. 13). 9½ x 7¼ inches; 67 pages. 12s. or 14.21 D. Kr.*

Publications in English on the Lapps are so few and of such uneven quality that any serious addition is a significant event for students of the arctic peoples. In this volume Gutorm Gjessing, Professor of Ethnography, University of Oslo, presents much material that has previously been available only to those acquainted with the Scandinavian languages. For the most part the book consists of his own accounts re-worked; four of the seven chapters are revised lectures delivered to audiences outside Norway. Although a definitive ethnographic description of the Norwegian Lapps is greatly needed to complement the work of Manker[1] and Itkonen,[2] this does not pretend to be it and must, therefore, be judged by other standards.

Gjessing's principal concern is that of "culture contact", and he begins by discussing the role of the Lapps in Scandinavian prehistory. His experience as an archaeologist makes him cautious about accepting the people of the Komsa and neolithic "Arctic" slate cultures as either ethnically or racially Lappish. But it is nonetheless certain that the earliest Nordic colonists found a Lappish population in Finnmark when they arrived in the eighth century. Gjessing's description of the process of settlement is excellent, and he has some stimulating observations on the expansion of reindeer nomadism, which he believes developed in the sixteenth century as a product of culture contact.

The chapter on "Culture contact during historic times" is refreshing, especially the remarks on the changing attitude towards the Lapps. The great Norwegian national renaissance was not accompanied by liberal ideas concerning the preservation of Lappish culture, but rather by repressive measures (such as the suppression of Lappish in school tuition) aimed at Norwegianization.

The kernel of the book lies in the three chapters describing three different Lappish communities in Norway: the Sea Lapps of Laksefjord, the settled River Lapps of Karasjok, and the reindeer nomads of Kautokeino. It is unfortunate that the author has had to lean so heavily on other people's accounts, the chapter on Laksefjord being based almost entirely on Falkenberg's fieldwork in 1938,[1] and that on Kautokeino upon Smith's work.[2] Neither of these men was interested in social structure, and it is hardly satisfactory to make their work the basis of theoretical generalization. There are ample data elsewhere with which Gjessing could test his hypotheses. The third study, that of Karasjok, is based on the author's own fieldwork of two months' duration—again scarcely a satisfactory basis for a study of "culture relations". Certainly his observation that there are elements of a caste structure in present day Karasjok suggests a cursory and naïve examination of the situation, or a very particular use of the term "caste". His tribute to British and American scholars working in Lapland is appreciated, but although such persons may have greater objectivity when studying the process of culture contact, the examination of historical material in

[1]Manker, Ernst. 1947. 'De svenska fjällapparna'. Svenska Turistföreningens Förlag hanbocker om det svenska fjället, 4. Stockholm: 548 pp.

[2]Itkonen, T. I. 1948. 'Suomen lappalaiset vuoteen 1945'. Porvoo: 2 vols.

[1]Falkenberg, J. 1938. "Bosetningen ved indre laksefiord i Finnmark optegnelser fra 1938" *in* 'Bidrag til Finnernes bygdehistorie og etnografi'. Oslo: Vol. 2, pp. 51–159.

[2]Smith, P. L. de F. 1938. 'Kautokeino og Kautokeino-Lappene . . .'. Oslo: xiv + 602 pp.

archives is surely better undertaken by a native of the country.

The book contains many stimulating ideas, and since the reader is warned on the third page that the work does not claim to be "exhaustive", one should not, perhaps, cavil at the absence of adequate substantiation of the author's theories by reference to ethnographic data, when these theories have been formulated before. The misquotation of scholars writing earlier, however, is to be severely condemned. Thus, Gjessing citing one of his own articles writes on page 26 "in Samish [Lappish] social structure also there are traits which are more closely related to the social forms of the Chukchee, Koryaks and Eskimo than to those of the Mongolian and Turkish peoples (Gjessing, 1947)". What he actually wrote in 1947 was "Solem suggests that the *sii'dâ*[1] is socially based directly on the hunting unit: consequently it is of considerable interest to point out that the social unit of village organization among the Chukchee, and among both Siberian and American Eskimos, is apparently the crew of large hunting boats, as stressed by Miss M. A. Czaplicka already in 1914. In other words, both the *sii'dâ* organization, probably occurring in North Scandinavian and North Russian hunters' cultures already early in the Stone Age, and the Chukchee and Eskimo types may represent a more primaeval stratum in arctic society than the common Siberian type. In that case the Eskimo *umialik* would correspond to the Lapp *sii'dâ-ised*, the chief or leader of a village. The Lapp *sii'dâ* has in any case, however, been more closely knit than the Eskimo village: for instance the Eskimos do not have any organization corresponding to the Lapp *sii'dâ* council (Skolt Lapp *norraz*)."[2]

There is no mention of the Koryaks, the Mongolians or the Turkish peoples, nor are his remarks couched in the same definite terms. This particular reference is discussed at length because there is a constant tendency throughout the book to give the work of earlier writers a nuance never intended, but which conveniently fits into Gjessing's argument.

The description of Læstadianism, the Christian revivalist movement, which, accompanied by ecstatic forms, still has widespread support among the northern groups of Lapps, is unfortunately most one-sided. Professor Gjessing repeats remarks published elsewhere that in Læstadian dogma the existence of God becomes of minor importance and that the system of ideas was created by Lapps and Finns. The reviewer, from several years contact with members of this group, believes these assertions to be entirely false. Læstadianism was principally created by Swedish-born Lars Levi Læstadius; his printed sermons are the only literature other than the Bible used by the preachers of this sect, and they contain continued mention of the function of God in Læstadian doctrine. Gjessing's observation that communion assumes a central position in the religious life of Læstadians is in direct contradiction to the reviewer's observations and those of Per Boreman, author of the best study of the movement.[1] Although Gjessing is right in emphasizing the socially cohesive character of the movement, his view that it constitutes some sort of a "covert" revival of the old pre-Christian shamanism is highly equivocal.

It is when he discusses sociological concepts that the author is most open to criticism, for emphatic reiteration is no substitute for scientific analysis. We have no real evidence that the *sii'dâ* has remained unchanged in its social functioning. Any attempt to correlate the incompletely understood titles given in early tax lists with present social positions is largely guesswork. Thus Gjessing's attempt to equate the *finnelensmann* and *chochstarus* of the old records with the contemporary leader of the *sii'dâ* and his assistant entails ignoring the possibility that the earlier positions were

[1]The *sii'dâ* is the unit of social organization of the reindeer nomads.

[2]Gjessing, G. 1947. "Norwegian contributions to Lapp ethnography". *J. Roy. Anthro. Inst.* (London). Vol. 77, pp. 50–1.

[1]Boreman, Per. 1953. 'Læstadianismen'. Stockholm.

officially imposed institutions similar to the Swedish authorities '*byordningsman* (Lappish, *jærjâstâs-olmus*). Nor have we any adequate evidence that the *sii'dâ* was exogamic. The assertation of one informant cannot replace examination of tax lists and their correlation with church registers.

In spite of all these defects this is an important book. It provides information for the non-Scandinavian reader, and gives an interesting stimulus to the whole field of Lappish research. Gjessing's views on historical matters are always interesting and often new, such as his comments on the effects of the development of reindeer husbandry, or the decline of the Pomor trade. He points out what is generally ignored: that our knowledge is defective since not only did the Lapps try to mislead missionaries, but the authors of such accounts as we possess were Lutheran missionaries who utilised Old Norse religious concepts to describe something entirely alien to them. Moreover, what they published was a mixture of information from different parts of Lapland. Professor Gjessing is to be congratulated in introducing fresh ideas to replace the arid study of these seventeenth century texts.

Another great virtue of the book is that it is a sympathetic account lacking the ethnocentricity and romanticism that has marred nearly all previous writings on this people. IAN WHITAKER

LAND OF THE LONG DAY

By DOUG WILKINSON. *Toronto: Clarke Irwin, 1955. 9¼ x 6¼ inches; vii + 261 pages; illustrations; maps on end papers. $5.00.*

This book is the account of the author's year-long stay at an Eskimo camp site in northern Baffin Island. It tells in factual but stirring words of his deliberately-sought life as an *inoongwah*, "one living in the likeness of an Eskimo". He had already an extensive knowledge of the north and its people as a maker of successful short films, (one of which has the same title as this book). In 1953 he went up as the adopted son of his friend Idlouk. He brought no access of white wealth or equipment to Idlouk's camp, only his rifle, sleeping bag and camera. He was determined to understand the Eskimo's problems from the inside, as a working member of their camp, in order to fit himself for *considering* the post he has now accepted with the Canadian government (Northern Service Officer, Department of Northern Affairs, at Frobisher Bay, Baffin Island).

In this showed the intensely idealistic spirit which flames from this young Canadian. Such a spirit often entangles a writer in a mesh of fancy and philosophising. But one looks in vain for such in Wilkinson's prose—as simple, beautiful, and eminently believable as his photographs. He has the power to convey the feeling of his hunter's life, times unpleasantly harsh as well as times gay and exciting. There are plenty who know the Eskimo well and cannot write descriptively: there are some unfortunately who can pour forth words based on misconception, ignorance, or plain lies. But most readers will agree that here is living, truthful writing, that conjures up this territory where the sun lives above the horizon for three months in summer, and below for as long a time in winter. One can enjoy with him the sights, scents, and sounds of returning spring, and marvel with him at the triumphant *auktok* seal hunt as performed by his foster father one day.

Through the pages his main theme and interest leaps out. How do the Eskimo and white man differ, and how can the already-present intermingling of their cultures be a blessing and not a disaster? He describes the lingering patience of the Eskimo, his apparent lack of gratitude, Idlouk's own reaction to the present days and distaste for returning to the ways of his ancestors. He is careful to point out that physically he had no trouble living in the likeness of the Eskimo—mentally he could not do so. On his last pages he writes thoughtfully about the future of the Eskimo in the Canadian north. He is not sure, but

in guiding hands like his the Eskimo has the best of opportunities.

Perhaps it is because he is back at work on Baffin Island that a few mistakes occur in his text; most of them are due to weak or alien proof-reading. Resolute Bay is described in very contrary directions from Pond Inlet, and as a Scot I cannot allow him to have Murdock for Murdoch unchallenged.

A well selected group of photographs, an index, and end paper maps round out this admirable volume. P. D. BAIRD

ARCTIC WILDERNESS

By ROBERT MARSHALL. Edited with an Introduction by George Marshall. *Berkeley, Calif.: University of California Press, 1956. 9½ x 6½ inches; xxvi + 169 pages; illustrations; maps. $3.75.*

Robert Marshall died 17 years ago at the age of 38. He left an impressive record of achievment including several publications, of which 'Arctic Village', published in 1933, is the best known. 'Arctic Wilderness', edited and introduced by George Marshall, is compiled from his brother's letters and notes and is in many ways supplementary to 'Arctic Village'. The earlier book deals intimately with the life of inhabitants of Wiseman, Alaska, whereas 'Arctic Wilderness' is the story of Bob Marshall's trips into a little known section of the Brooks Range. These extensive travels by foot, boat, and dogsled, are well documented and the topography of the region is enthusiastically described in a joyous and almost poetic style.

A map prepared in the field by Marshall and first published in 1934, is republished in 'Arctic Wilderness' with some revisions based on later expeditions. In 1934, this map was an important contribution to the knowledge of the geography of the northern Koyukuk region.

Marshall's wilderness remains today essentially as he saw it, even though the Alaskan Arctic has been a beehive of activity for the past 10 years. An extensive exploration project north of the Brooks Range at one time included plans for a pipeline across the mountains through the heart of his wilderness. Military and other governmental mapping activities in the Brooks Range and to the north have eliminated almost every blank spot from the map. The region Marshall so laboriously traversed and mapped was remapped during the war from aerial photographs, and is now being mapped again in greater detail with the use of helicopters and aerial photographs. The Arctic Divide, which was one of Marshall's goals, has been reached and crossed at four localities by ground motor vehicles, and air travel across the wilderness is now on a regular schedule. All this has had, however, little effect on the Koyukuk region; many of the "majestic summits", "knife-edge ridges", "snow-covered limestone crags", "sheer falls", and "Yosemite-like valleys" have not been visited by a human being since Bob Marshall left.

Marshall also collected data on tree growth at the northern timber line. Although the data are not presented, the introduction states that his observations "seem to substantiate his theory that the northern timber line in Alaska is not the result of unfavorable environment for tree growth, but simply of the fact that there has not been time since the last ice sheet receded for the forest to migrate further north."

'Arctic Wilderness' provides an insight to the author's character and his views on a great variety of subjects, including the value of physical exploration. Although Marshall recognized the similarity of mental adventure and physical adventure, his expeditions recorded in this book were motivated (in his own words) by "the thrill of adventure" and "the fact that exploration [physical] is perhaps the greatest aesthetic experience a human being can know. My own belief, which I realize the majority do not share, is that most exploration today is not of material value to the human race in general but is of immense value to the person who does it. Furthermore, I feel that one of the great values of explorations is in pitting oneself without the aid of machinery against unknown nature."

'Arctic Wilderness' is an interesting, refreshing, and enjoyable book, especially to those readers who, like Bob Marshall, thrill at "simply the joy of triumphing over something which is difficult to accomplish" and "setting foot where no human being has ever trod before."

GEORGE GRYC

NORTHERN TREASURY. SELECTIONS FROM THE BEAVER

Edited by CLIFFORD WILSON. *Toronto: T. Nelson and Sons, 1955. 8¾ x 5½ inches; viii + 238 pages; plates; maps. $3.50.*

Most readers of *Arctic* are probably quite familiar with the magazine *The Beaver*, published by the Hudson's Bay Company, and will, therefore, welcome this anthology of favourite articles. The editor of *The Beaver*, Clifford Wilson, has selected a cross-section of articles from as far back as 1933, and has tried to retain the variety usually found in each issue. Those who do not possess the early issues of *The Beaver* will find this compilation interesting and entertaining.

Readers will be amused again by the light comedy of Stephen Leacock, James McCook, and Eric Nicol; they can read of arctic adventure as told by Martin Bovey, Captain Mack, and Jimmy Bell. There is early history in the accounts of Douglas Mackay, R. C. Wallace, and Mrs. Hewlett; and not forgotten are the people of the north—the Indian and Eskimo, as described by Alfred Copland, Axel Neilsen, and Bishop Marsh.

A total of twenty-four articles has been assembled in this volume, for which a short introduction was written by Leonard Brockington. The general reader will find the book entertaining, and the arctic specialist will find relaxation in the easy writing concerning his favourite region, the Northland.

J. LEWIS ROBINSON

INSTITUTE NEWS

Applications for the position of Executive Director

The Board of Governors invites applications for the post of Executive Director of the Arctic Institute, which position has been held by Mr. T. H. Manning on a part-time, temporary basis for the past year and a half. Mr. Manning wishes to relinquish this position not later than October 31. The new appointment will be on a full-time basis at a salary commensurate with the applicant's qualifications. The Executive Director will be required to live in eastern Canada.

Applications should be addressed to the Director of the Montreal Office.

'Arctic bibliography', Volume 6

The sixth volume of 'Arctic bibliography' was published by the U.S. Government Printing Office in April 1956. Like the preceding five volumes it was edited by Miss Marie Tremaine, and prepared by the Arctic Institute for the U.S. Department of Defense. A Directing Committee, of which Dr. Henry B. Collins is the chairman, exercised general supervision.

Volume 6 lists and describes the contents of 5,285 English and foreign language publications in all fields of science relating to the arctic and subarctic regions of America and Eurasia. Subjects emphasized are geology and mineral resources; geography; zoology; medicine and physiology, especially the effects of low temperatures; engineering (navigation, aeronautics, construction, transportation); agriculture and forestry; meteorology; oceanography; anthropology and sociology; and exploration, especially Russian expansion in the north Pacific. Language coverage is similar to the earlier volumes, 3,225 of the publications listed are in English, 1,215 in Russian,

350 in German, and the remainder mainly in French and the Scandinavian languages. Titles of the foreign language publications are given in the original and in English, with an abstract or summary of the contents in English. Publications are listed alphabetically by author and the contents are indexed and cross-indexed according to major geographical areas and specific localities as well as by topic and sub-topic.

The six volumes of 'Arctic bibliography' form a valuable key to existing sources of arctic information in the principal libraries of the United States and Canada, and comprise the most comprehensive annotated regional bibliography ever assembled.

A limited number of the earlier volumes are still available and may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. at the following prices: Volumes 1–3, 20,003 entries and 4,478 pages, $12.75 (sold by the set only); Volume 4, 7,627 entries and 1,591 pages, $5.25; Volume 5, 5,494 entries and 1,268 pages, $4.75; Volume 6, 5,285 entries and 1,208 pages, $4.50.

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The Institute library gratefully acknowledges gifts of books, reprints, and maps from the following persons and organizations:

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Complimentary copies of the following periodicals have been gratefully received during the past year:

Alaska. University. Biological Papers.
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Gifts to the Institute

The Chairman and Board of Governors most gratefully acknowledge the following gifts during the 1955 calendar year.

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'The mammals of Keewatin'

In September 1956 the University of Kansas Museum of Natural History will publish 'The mammals of Keewatin' by Francis Harper. This publication, which presents accounts of 34 mammals of the Keewatin District, Northwest Territories, Canada, is based upon six months field work at Nueltin Lake and vicinity, along the edge of the Barren Grounds. The field work was carried out under the auspices of the Arctic Institute of North America. 'The mammals of Keewatin' is 80 pages long, including bibliography and index; it is priced at 75 cents and is available from the Washington Office of the Arctic Institute.

NORTHERN NEWS

An archaeological reconnaissance in the Coronation Gulf region

During July and August 1955 Professor Elmer Harp, Jr., Department of Sociology and Anthropology, Dartmouth College, Hanover, New Hampshire, and Dr. Ralph E. Miller, Professor of Pathology, Dartmouth Medical School, conducted an airborne archaeological reconnaissance of certain areas adjacent to Coronation Gulf. The purpose was to seek traces of prehistoric cultures in the central Arctic which might more clearly link together the early cultures of Alaska with those of the eastern Arctic. This research was supported by a major grant from the American Philosophical Society and a supplementary award from the Research Committee of the Faculty of Dartmouth College.

The trip was made in Miller's aircraft, a Piper Tripacer powered with a 135 h.p. Lycoming engine, and equipped with dual flight controls and Edo 2000 floats. The Piper normally accommodates four passengers, but the two place rear seat was removed to enlarge the stowage space for camping gear, and an auxiliary gas tank was fitted which increased flying time to five hours. By prior arrangement with the Hudson's Bay Company, caches of aviation gas were established at Coppermine and Bathurst Inlet, and Associated Airways, Ltd., of Edmonton, contracted to deposit other caches at Dismal Lakes, Tree River, and Contwoyto Lake. Imperial Oil laid in two steels at Sawmill Bay on Great Bear Lake, and Wardair Ltd. kindly made its Port Radium cache available for emergency use.

The party departed from the Connecticut River at Hanover on July 2, and in near-perfect weather were able to maintain their planned schedule to Coronation Gulf with overnight stops at Bay City, Michigan; Duluth, Minnesota; The Pas, Manitoba; Fort Smith, and Port Radium, Northwest Territories. They reached Coppermine on the morning of July 7, and for the next few days enjoyed the cordial hospitality of Mr. and Mrs. David Wilson of the Federal Day School. Valuable information was obtained from the inhabitants of the settlement, and flights were taken into the surrounding country and up the west coast of Coronation Gulf as far as Locker Point; trips were also made by boat and on foot to Bloody Falls and to "Cemetary" Island, where a trial excavation was begun in one of a series of house pits on a raised beach.

The week of July 11 to 17 was spent in the Tree River area. From base camp, near the former site of Port Epworth on the southeast side of the estuary, air surveys were carried out in the Tree Valley and day-long flights were taken west to Kugaryuak River and north to Hepburn Island. Extensive ground surveys were made on both sides of the Tree estuary, the river itself below the twelve-mile falls, as well as parts of the granite country which bounds the valley on the east.

On July 18 the party flew along the coast to Bathurst Inlet. There Asgar "Red" Pederson of the Hudson's Bay Company was a most helpful and delightful host while investigations were made around the mouth of the Burnside River, the Western River at the southern end of Bathurst Inlet, and on some of the islands extending north to Banks Peninsula. The next camp was set up on July 21 near the mouth of the Hood River in Arctic Sound; although stormbound there for three days, most of the country immediately west of the river was surveyed as far south as the confluence of the James River.

The night of July 25 was spent at Bathurst post and on the next day the

party flew to Contwoyto Lake. There, by invitation, the island tent camp of Associated Airways was used while the embayments of the eastern shore were explored. Particular attention was paid to the numerous eskers including a major esker complex midway on the western shore. The return flight to Bathurst was made on July 31 with a stop of several hours in order to check a series of house rings on a large island in the Burnside River about five miles east of Lake Kathawachaga.

On August 1 the survey returned to Coppermine, following a cross-country route up the James River, out to the Tree estuary for refuelling, and thence along the coast. Once more the gracious hospitality of the Wilsons was accepted. Investigations were extended in the vicinity of the settlement, the mouths of the Rae and Richardson rivers, and for several miles along the north bank of the Rae. The excavation of the house pit on "Cemetary" Island was completed, and the entire coast between Coppermine and Cape Krusenstern was carefully observed on several low-level flights. On one of these a landing was made in order to examine the stone houselike structure on the bluff behind Locker Point.

The party moved inland to Dismal Lakes on August 9 and set up the last major camp of the season at the lower narrows. The weather was unfavourable here, but large areas were scouted from the air and, from suitable landing spots, good ground coverage was obtained around the shores of Dismal Lakes and at Kamut Lake, near the great bend of the Coppermine River.

Finally, on August 20 the first move was made towards home. From Dismal Lakes the party flew westward to Sandy Creek and down the Dease River to Great Bear Lake. Landings were made at the mouth of Sloan River and at Sawmill Bay and then a two-day camp at Fishtrap Lake, a few miles to the southeast. After reconnaissance there, the survey flew out to Fort Smith and thence by much the same route as before to Hanover, arriving on the afternoon of Friday, August 26.

At this time no intensive analysis of the archaeological findings has been made, but certain descriptive formulations can be drawn. The artifacts collected along the coasts must be attributed to modern, or relatively recent Eskimo. Most of the artifacts are of bone, horn, or wood, and are very common types, including arrow points, harpoon heads and fore-shafts, fish spear prongs, fish lures and hooks, barbed dart points, scrapers, blubber pounders, picks, spatulas, various hafts, wood bowls, soapstone lamps and pots, and various elements of dog harness. A number of the projectile points and knives have blades of native copper, and several are of iron. Preliminary inspection indicates that the greatest age is represented in a series of harpoon heads from Cape Hearne which are of Late Thule type.

The interior sites around Dismal Lakes and Kamut Lake suggest much greater antiquity. Two distinct complexes of chipped stone artifacts were found on eskers and raised beaches. One of these, the more common and widespread of the two, consists of large, often coarse and undifferentiated forms of scrapers, and projectile points or blades which seem to resemble closely Yuma and Plainview types. The other is a microlithic complex consisting of lamellar blades, some retouched, minutely flaked end- and side-blades and scrapers. No burins have been distinguished in this material, which came mainly from one site on the north shore of Dismal Lakes. This latter complex is undoubtedly related to that widespread manifestation of similar industries which may, in the New World, stem from the Cape Denbigh Flint Complex of western Alaska. It may also represent some intermediate stage of cultural development in the central Arctic which, although still orientated to inland subsistence patterns, led ultimately to the growth of the Cape Dorset, or other early sea-hunting cultures of the eastern Arctic. More detailed research on these collections may help to clarify some of these postulated relationships.

ELMER HARP, JR.

Russian plans for the Ob' and Yenisey and the Bering Strait

On 3 March 1956 *The Financial Post* (Toronto) published a front page story on the possible effects of the supposed Russian plans to dam the Ob' and Yenisey rivers, and the Bering Strait. The waters of the Ob' and Yenisey are, according to this plan, to be deflected southward to irrigate areas at present short of water, while the Bering Strait plan involves the pumping northwards of very large quantities of Pacific water from the Bering Sea. Certain facts seem wrong with the plan as reported, and with the interpretation of the possible effects. As the whole scheme is on a titanic scale, and will undoubtedly merit more publicity, the following random comments may be of interest.

It has been suggested that if the Ob' and Yenisey rivers were dammed the temperatures in the Arctic Ocean near the mouths of these rivers would decrease, and that the winters of north-western Europe would suffer in consequence. At present when the two rivers reach the Siberian coast they have lost a great deal of heat, and their effect in delaying the freezing of the sea in that region, or of fending off polar pack ice must be small. Moreover, the prevention of so much fresh water from entering the sea would tend to increase the salinity of the water in that region, thus increasing its density and decreasing its stability. This would encourage water from below to rise to the surface; the water underlying the upper Polar or Arctic water in the Arctic Ocean is Atlantic water from the Atlantic Drift (known nearer its source as the Gulf Stream), and this water at the surface would bring warmer not colder conditions.

The damming of the Bering Strait would, according to *The Financial Post* and other reports of this plan, stop "the flow of cold arctic water into the Pacific". What flow? There is no evidence for any southward movement of water through the Bering Strait, only of a northward movement of Pacific water from the Bering Sea. The Russians presumably wish to accelerate this northward flow, and to do so it is necessary to dam the strait in order to stop any back-flow (south) of the water they pump or drive north.

One can only attempt an "educated guess" as to what would happen to the Pacific water pumped into the Arctic Ocean. It would sink below the arctic upper water (as the Atlantic inflow does in the Spitsbergen area), float on top, or mix with the polar water according to the temperature and salinity of the two water types, as density is a function of these two properties. The mean yearly temperature and salinity of the water flowing north through the Bering Strait are about 0°C, perhaps a little higher, and about 32 parts per thousand respectively, values which are fairly close to those normally found in the upper Arctic water in the Arctic Ocean. Since the water to be pumped under the Russian scheme must be Bering Strait water a considerable amount of mixing might be expected. However, the Bering Strait inflow is somewhat warmer than 0°C in summer, while the Polar surface water hardly rises above that figure, and in winter the Arctic Ocean is probably higher in salinity than the Bering Sea water. This suggests that the Bering water would float on top of the Polar water. Again, the Bering water arriving in the Arctic Ocean would lose heat to the air, which would tend to bring the densities closer together and encourage mixing.

To have any significant effect enormous quantities of water must be pumped across the proposed Bering Strait dam. The present inflow from the Bering Sea to the Arctic Ocean is about 0.3 million cubic metres per second, which is only about 1/10 of the inflow from the Atlantic in the region between Iceland and the north of Scotland. Moreover, whereas the average temperature of the Bering Sea inflow is around 0°C, that of the Atlantic inflow to the Arctic Ocean is about 8°C, a very large difference. Because of its high salinity the Atlantic water sinks beneath the water of the Arctic Ocean, and although it has an

important warming effect on the climate of Norway and northwest U.S.S.R., it does not manage to keep the Arctic Ocean itself free of ice.

Another problem concerns the rate at which the water pumped from the Bering Sea would lose heat to the polar air mass above. This air mass is large and comparatively stable, and a very great rise in the heat budget of the Arctic Ocean would be necessary for it to be seriously affected. At present Pacific influence north of Bering Strait extends to about 76°N., the northern limit of the Chukchi Sea; planktonic species are known from that latitude, and the summer limit of ice is farther north in that region than to the east and west of it. Using these data to estimate the effect of increasing the flow of Pacific water through the Bering Strait, if the northward flow were maintained at twice the present natural flow, the area influenced to the same extent as the Chukchi Sea today would be approximately doubled; this assumes that Pacific water stays at the surface, which is probable. If the inflow were three times the present rate, the area influenced would be trebled, and so on until "diminishing returns" reduced the area influenced. If water could be pumped at five times the present natural flow, that is at about 1.5 million cubic metres per second, an increase of 1.2 million cubic metres per second over the present inflow, the southern limit of the polar pack would probably be pushed back only a few tens of miles over a front of about 50 to 60 degrees of longitude. The effect on the polar air mass would not be very great.

The problem of where the Pacific water would go appears to have been overlooked. It has been assumed that the water pumped over the Bering Strait dam would turn westward and hold to the Siberian coast, thus freeing the northern sea-route from ice. There is no good reason for this to happen. The earth's rotation deflects moving bodies of large mass to the right in the northern hemisphere and the rotational force is greatest at the pole, zero at the equator. Thus water entering the Arctic Ocean from Bering Strait would tend to turn east. In fact, the Pacific water turns along the Alaskan coast where it is stopped, for the most part, by pressure from the Arctic Ocean circulation itself; much or most of the Pacific water is then forced north and finally westward in the Chukchi Sea area. From this region the general Arctic Ocean circulation continues in a clockwise direction, but the main current keeps well out from the Siberian coast. Along the Siberian coast and over most of the continental shelf in that region, the current is in the opposite direction, to the east, and is made up of Arctic and *Atlantic* water that comes mainly from the Kara Sea.

An increase in the Pacific (Bering Sea) contribution to the Arctic Ocean would, therefore, probably be felt not along the Siberian coast but along the northwest coast of Alaska as far as Point Barrow, and in the northern part of the Chukchi Sea. The summer ice limit would be pushed north, and if the Pacific contribution were large enough, the warming effect might penetrate a considerable distance across the middle of the Arctic Ocean, where the present current apparently leads across the basin towards northwest Greenland.

The overall effect on the climate in the sea and in the atmosphere would depend on the amount of water pumped over the Bering Strait dam. This would have to be at least as great in quantity as the present Atlantic inflow to have any important effect, and even then it would be in competition with two very large and stable bodies which themselves dominate the northern climate, the polar air mass and the Greenland Ice Cap. It would probably make only a very small impression. Also, it should be remembered that warmer water, and water ice free for longer periods in the year would incerase the moisture in the air, and therefore the precipitation; some of this would fall as snow on the Greenland Ice Cap and the arctic islands of Canada *increasing* the rate at which ice formed.

The two outflows from the Arctic Ocean are: the East Greenland Current, which flows south along the east Greenland coast, and after turning Kap Farvel,

forms part of the West Greenland Current: and the Canadian Current which flows south along the east coast of Baffin Island, and is composed of water which has come through the arctic archipelago. The flow of both these currents would be increased by the present plan.

The present total inflow into the Arctic Ocean is about 3.55 million cubic metres per second, allowing for evaporation from the sea surface. This is shared as outflow by the East Greenland Current, with an approximate transport rate of 2.20 million cubic metres per second, and the Canadian Current with about 1.35 million cubic metres per second. If water were pumped over the Bering Strait dam at five times the present flow, the inflow would be increased by 1.2 million cubic metres per second. This in turn would raise the transport of the East Greenland Current from 2.20 to about 2.95 million cubic metres per second, and the Canadian Current from 1.35 to about 1.80 million cubic metres per second. Both these increases would affect the Canadian waters on the eastern seaboard, and therefore, the climate, because the East Greenland Current becomes part of the West Greenland Current that eventually crosses to the Canadian side of Baffin Bay and the Labrador Sea. The amount of warming would depend on the level of increased Pacific inflow that can be maintained. If the maximum level were five times the present rate, it is possible that the additional heat would be absorbed by the polar air mass, in which case the climate of eastern Canada might become cooler. If the level were ten or fifteen times the present rate, the temperature of the outflow itself might conceivably be raised, and then the climate of eastern Canada might become warmer. This, however is pure speculation.

It is not intended here to guess at the effect of the Bering Strait scheme on the productivity of the waters concerned, although there would undoubtedly be some changes. So much depends on the precise levels at which the pumps could operate that it is useless to go farther along this line of thought at present. There would certainly be a period of confusion before conditions settled down to a new equilibrium. M. J. DUNBAR

Limnological investigations in northern Quebec

From 16 May to 17 September 1955 G. Power and the writer carried out freshwater investigations in the Lac Aigneau district, northern Quebec. The studies were supported by McGill University-Arctic Institute Carnegie Scholarships and by a grant from the Quebec Department of Game and Fisheries. Lac Aigneau, which is part of the Koksoak River system and lies approximately eighty-five miles southwest of Fort Chimo, was reached by chartered plane from Fort Chimo.

Power studied the life history and physiology of the salmonoid fishes. It had been hoped to obtain data on the biology of the sea-run Atlantic salmon (*Salmo salar*) at the northern limit of their range in Canada, but unfortunately only land-locked salmon were found in Lac Aigneau; an extensive series of rapids and falls on the Rivière Aigneau prevented the ascent of sea-run salmon from Larch River to Lac Aigneau. A few sea-run salmon parr were obtained from the Clearwater River, where a limited amount of time was spent. Power, therefore, concentrated on the collection and analysis of brook trout (*Salvelinus fontinalis*), and of land-locked salmon and arctic char (*Salvelinus alpinus*). He used an apparatus for measuring the oxygen requirements of a number of brook trout under field conditions.

The writer was mainly concerned with a general investigation of Lac Aigneau, which included sounding the lake and the taking of temperature, oxygen, and pH determinations periodically throughout the summer. The plankton and bottom fauna were quantitatively sampled, and 19 overnight net sets were made with a standard gang gill net. It is hoped that results from this study will contribute to the knowledge of the productivity and classification of northern lakes and provide further information on the distribution of freshwater organisms.

D. R. OLIVER

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